5-30
H.H.

TRANSACTIONS

OF THE

HERTFORDSHIRE NATURAL HISTORY SOCIETY.

VOL. VI.

TRANSACTIONS

OF THE

HERTFORDSHIRE

NATURAL HISTORY SOCIETY

AND

FIELD CLUB.

EDITED BY JOHN HOPKINSON, F.L.S., F.G.S.

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,, II.	(pp. lx and 260).	....	June, 1880.

Transactions of the Hertfordshire Natural History Society.

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PROCEEDINGS

OF THE

HERTFORDSHIRE NATURAL HISTORY SOCIETY.

Ordinary Meeting, 16th October, 1889, at St. Albans.

F. M. Campbell, Esq., F.L.S., F.Z.S., etc., Vice-President, in the Chair.

Mr. William Harford, The Manor House, Bushey, Watford; Mr. F. G. Kitton, Hillside, St. Albans; Mrs. Quincey Lane, Berkhamsted; the Venerable Archdeacon Lawrance, M.A., The Rectory, St. Albans; Mr. Richard Lydekker, B.A., F.G.S., The Lodge, Harpenden; Mr. Edward H. Norman, Moor Place, Much Hadham; Mr. J. G. E. Sibbald, 3 Townshend Villas, Richmond, Surrey; and Mr. J. Woolsey Spackman, The Daltons, St. Albans, were proposed for membership of the Society.

A lecture was delivered of which the following is a somewhat abridged report:—

"Rabies and the Pasteur Institute." By John Evans, D.C.L., LL.D., Treas. R.S., Pres. S.A., F.L.S., etc.

Dr. Evans said that, having been asked to give the opening lecture of the session, he had selected this subject of Rabies and the Pasteur Institute, 1st, because it was, he believed, a matter of general interest, touching as it did upon the disease of hydrophobia and its cure, and 2nd, because he had recently visited and inspected the Institute in Paris. He had also had the advantage of hearing a lecture before the Royal Society upon the subject, delivered by an assistant of M. Pasteur himself. Since then the matter had attracted very considerable interest. Sir Henry Roscoe had made it the subject of an address at the Midland Institute, and there had been a considerable number of magazine articles published upon it. It had been suggested that this might be more a medical than a natural history topic, but it appeared to him that anything which referred to organisms, even of the low forms which he should have to mention, was not out of place. Of course the subject was closely connected with many animals, and particularly with the best and most intelligent of our domestic animals, the dog; but it did not seem to him necessary that they should discuss the disease of hydrophobia at all.

The practice of inoculation as a preventive of an attack of disease was not a modern one. It was known to what he might call the lower races of people, such as the former inhabitants of Wales and Scotland, and had been in use for smallpox by Arab physicians since an early period. It was well known that there were some diseases which, having once attacked the human frame, were not likely to recur, or if they did so, it was usually in a very mild form. Such were small-pox, which rarely reappeared; measles, which did so more frequently; and even the plague. The idea was that when such a disease attacked a person, it exhausted a certain part of the frame in the same manner that fungi exhausted certain constituents of the soil where they grew, and travelling outward to obtain fresh supplies, formed those "fairy rings" with which we are familiar. Inoculation for small-pox was the first known application of the principle. This was introduced from Constantinople into London as early as 1721. The practice was to inoculate a healthy person with virus taken from some one who had had the disease in a mild form, and among the first who promoted this system was Lady Mary Wortley Montagu, whose delightful letters no doubt some of those present had read. Her example was followed by the Princess of Wales in 1722, who allowed her children to be inoculated. Among those who had been inoculated the deaths from small-pox were only about one in sixty cases, whereas in three years 2,351 deaths had occurred in 14,559 cases of small-pox among those who had not been protected in this manner, or about one in six; thus the system reduced the mortality to one-tenth of what it had previously been. The practice was mainly confined to England, but in 1762 the Empress Catherine of Russia sent to this country for a physician to inoculate her, and the ancestor of one of our county representatives—Baron Dimsdale—earned his title by proceeding to Russia, at considerable risk to himself, for that purpose. But after all under inoculation many children were disfigured and one in 300 or 400 cases died.

Then came the age of Jenner. Dr. Jenner, a Berkeley physician, was aware of the fact which had been observed in several districts of Gloucestershire and elsewhere that those who caught a certain eruptive disease from cows in milking them were practically exempt from small-pox. He enquired in 1776 into these statements, and found that they were founded on fact, and he soon afterwards introduced vaccination. Of course the protection was not perfect, and lasted only a certain number of years, but even after that time a person had the disease, if at all, in a much milder form. Objections were taken then to the introduction of vaccination, just as they are now to its being performed—the opposition at the present time seems to have become so great, that they had actually, after vaccination had been in use a hundred years, a Royal Commission sitting to enquire whether it really was of any service. Of course objections would be raised in a similar way to the introduction of inoculation for hydrophobia, but he thought it would be generally admitted that M. Pasteur had made wonderful discoveries.

What Jenner had done for small-pox, Pasteur has done for hydrophobia, and even more. The discovery of a cure for this terrible disease was not, of course, a sudden one, but had been led up to by a series of experiments and studies during forty years. In the course of investigations he found that certain substances, identical in composition, were possessed of very different properties. For instance, he proved that there were two kinds of tartaric acid, and he further discovered that these could be separated by certain treatment during the process of fermentation. Led thus to study minutely the nature of fermentation, he found it to be due to the presence and the action of minute organisms, and that if these were excluded no fermentation went on. This led him to the discovery that the air was full of germs or seeds of disease, and it was this discovery which had suggested to the eminent surgeon, Lister, the antiseptic treatment which had since been used with such beneficial results. M. Pasteur set himself to cultivate these germs, and the idea then occurred to him that there might be some means of modifying them, as other plants were modified under culture. This he found was possible, and consequently that he could inoculate persons so as to protect them against certain diseases, for his discovery was that virus, by the conditions of special culture, might be reduced to a condition in which it was no longer injurious to animals inoculated with it. His attention was for some time occupied with the study of a disease of silkworms, which had wrought great havoc with the silk trade of the south of France, and this he was completely successful in curing. He then entered upon the study of a disease of fowls, known in France as "chicken cholera." Microscopical examination showed that the blood and tissues of fowls thus diseased were filled with organisms known as bacilli, characterized in this case by a short stump-shaped body, nearly as broad as long and rounded at both ends. Healthy fowls inoculated with a trace of this blood, fell sick and died within a few hours, and the blood of this second creature contained innumerable microbes. These microbes could be cultivated artificially in chicken broth, but however many times the transference of virus from one animal to another took place, they lost none of their virulence. The artificially raised microbes, however, when exposed to pure air, gradually lost their poisonous qualities until they were no longer injurious, and animals having been inoculated with this attenuated form of virus were protected against the most virulent action of the poison.

Pasteur's attention was then directed to anthrax in cattle, sheep, and sometimes human beings, and this disease was discovered to be produced by long intermatted filament-shaped organisms. His cure on the same principle for this disease was completely successful, and at the present time his system of inoculation was used to an enormous extent in France. Since 1881, no less than 1,700,000 sheep and 90,000 oxen had been inoculated and thus protected. Last year the figures were 262,599 sheep and 34,464 oxen. The mortality in sheep in districts where anthrax prevailed

had by this means been reduced from ten per cent. to less than one per cent., and insurance offices refused to issue policies on animals not so treated.

In 1880 Pasteur devoted his attention to rabies. This, though often called madness, was not so in the sense of a loss of mental power, but was rather of the same nature as the delirium attending fever. Pasteur found that the spinal cord of rabbits inoculated with rabies was highly poisonous immediately after death, but that in about a fortnight it gradually became harmless. After a bite by a rabid animal the disease generally took some considerable time to develop itself, the virus having to reach a nervous centre, and it was thus possible for the artificially prepared virus to out-race it, by the animal's daily inoculation with an attenuated virus from a rabbit, beginning with an almost harmless preparation and leading up to a dose which, had the animal not been prepared by the previous treatment, must have been fatal. It was then safe against the effect of the bite. But he must be a bold man who would first attempt this experiment upon a human being. In front of the Pasteur Institute in Paris there is a bronze statue of a shepherd boy fighting a rabid dog. This was no fancy picture, but a representation of an actual fact. In July, 1885, a flock under the care of a shepherd in Alsace was attacked by a rabid dog, and the boy ultimately killed it with his *sabot*, but was dreadfully bitten on the face and head in the fight. This boy and his mother came up to Paris, and the mother implored M. Pasteur to treat her son with the inoculation which had had such beneficial effects among dogs. M. Pasteur was not a surgeon but a chemist, and he called in the best medical aid, but the case was regarded as hopeless. The experiment was however made, and with complete success, for the boy has entirely recovered and is still alive. Since then 7,000 persons had been treated at the Pasteur Institute in Paris, and there are no less than twenty such institutions in existence, chiefly in Europe and America. The success of the smaller institutions is rather remarkable. The usual mortality among persons bitten and not treated according to the system, is about 14 per cent., whilst of those who have undergone treatment, it is about 1 per cent. Of those bitten in the face and head, 80 per cent. died, but, at the Paris Institute, only 4 per cent. At Odessa, in 1888, 364 patients were treated, and the death rate was 0·83 per cent. At Palermo 109 were treated and not one died, and at the Warsaw Institute, of 370 patients proved to have been bitten by rabid dogs, not one had died. In Paris, in 1887, 350 persons were bitten, and 306 persons were treated, of whom three died. Forty-four declined treatment; of these seven died, showing a mortality 15 times as great. Of course it was hardly to be expected that every case would be equally successful. The virus from a bite would often take a strong hold of a patient, and if any delay took place before administering the antidote, a nerve centre might be attacked before the remedy had time to work. It was a remarkable thing that though they had attained this success, the

nature of the virus was entirely unknown. If it was produced by a microbe, as seemed probable, the most powerful microscope had yet failed to show its existence. It was also interesting to note that in the diseases such as he had mentioned, it was not the direct effect of the microbes which produced death, but rather their indirect action in producing poisonous fermentation in the juices of the body, or forming active poisons termed ptomaines.

Of late, experiments have been carried on with the object of finding, if possible, a similar cure for diphtheria. The experiments which he had enumerated served strongly to show our ignorance as to our relations with that extremely minute yet most powerful organism, the microbe. It is possible that we are dependent on these bodies not only in disease but in health, to an extent greater than was ever imagined. We know little of the action of our digestion, and it is possible that not only in that, but in numberless processes of nature, we owe far more to these organisms than to any action in inert substances.

Dr. Evans then proceeded to give a short description of the Pasteur Institute, in which building he was struck, he said, with the wonderful cleanliness and order which prevailed, which was hardly such as one might have expected in a place devoted to the preparation of such deadly poisons. A great part of the building was given over to the preparation of inoculations for sheep and cattle, as protection against anthrax, and it was chiefly from the sale of these—the price being only about twopence a dose—that the institution was supported. The Institute itself was perfectly free for human patients. It had been built by public subscriptions, to which, he regretted to say, this country contributed but a very small amount. Every convenience for laboratory work was provided, open freely to any properly-recommended student. A complete register of every circumstance connected with the cases treated was kept, the cases being classified as those of persons (1) bitten by supposed hydrophobic dogs, (2) those certified as suffering from the disease, and (3) those proved by experiment to have rabies. The operation was almost totally painless, and throughout the Institute there was nothing which suggested the smallest degree of animal suffering.

There had been some talk of establishing a Pasteur Institute in London, but it had not been thought necessary, considering the very short time in which Paris could now be reached from our capital, and the fact that anthrax, being almost entirely stamped out in this country, and inoculations for it uncalled for, no revenue could be obtained from its treatment. Isolated as this country is, it was possible that hydrophobia itself might be trampled out. But after the manner of English lovers of liberty, they were doing the work in a very piecemeal way. If they could make some general arrangement that for a definite period no dogs should be able to be at large in a condition in which they could bite others, something might be done towards this end. Perhaps when our County Councils get a little more into working order they might look to

them to do something. But whether or no the disease could be stamped out in this country, they ought all to feel, and, if possible, to show their admiration and gratitude to one whose patient and disinterested researches had opened to mankind a way by which, under Providence, to escape one of the most cruel, and, at the same time, inevitable of deaths. To all interested in natural history, the labours of M. Pasteur on some of the lowest and most obscure, and at once most powerful of living organisms, must of necessity commend themselves, and when they considered the enormous amount of suffering, both by the lower animals and man, that he had removed or alleviated, they might well greet him as one of the greatest benefactors to the world of animated nature.

Ordinary Meeting, 19th November, 1889, at Watford.

The Right Honourable the Earl of Clarendon, President, in the Chair.

Mr. William Harford, Mr. F. G. Kitton, Mrs. Quincey Lane, the Venerable Archdeacon Lawrance, M.A., Mr. Richard Lydekker, B.A., F.G.S., Mr. E. H. Norman, Mr. J. G. E. Sibbald, and Mr. J. W. Spackman, were elected Members of the Society.

Mr. J. Watson Neish, Highfield, Watford, and Mr. Digby S. W. Nicholl, F.L.S., F.G.S., The Ham, Cowbridge, Glamorganshire, were proposed for membership.

The following lecture was delivered:—

"The Diseases of Plants due to Fungi." By George Massee, F.R.M.S., University Extension Lecturer.

Ordinary Meeting, 17th December, 1889, at Watford.

George Rooper, Esq., F.Z.S., Vice-President, in the Chair.

Mr. G. Watson Neish and Mr. Digby S. W. Nicholl, F.L.S., F.Z.S., were elected Members of the Society.

Mr. F. W. Headley, M.A., Haileybury College, Hertford, and Mr. H. Reynolds Solly, Serge Hill, Bedmond, were proposed for membership.

The following lecture was delivered:—

"Notes on a Visit to Italy." By A. T. Brett, M.D.

Ordinary Meeting, 20th January, 1890, at Watford.

George Rooper, Esq., F.Z.S., Vice-President, in the Chair.

Mr. F. W. Headley, M.A., and Mr. H. Reynolds Solly were elected Members of the Society.

Mr. R. H. Bookey, B.A., Oak Vale School, Berkhamsted; Mr. C. J. Gilbert, F.G.S., Plas Gwyn, Berkhamsted, and Mr. Charles E. Jones, Russell Farm, Watford, were proposed for membership.

The following paper was read:—

"Seeds and Fruits; their Structure and Migrations." By A. E. Gibbs, F.L.S. (*Transactions*, Vol. VI, p. 16.)

Mr. T. J. Broad and Mr. E. M. Chater were nominated auditors of the accounts for 1889.

Anniversary Meeting, 21st February, 1890.

(At Watford.)

The Right Honourable the Earl of Clarendon, President, in the Chair.

The Report of the Council for 1889, and the Treasurer's Account of Income and Expenditure, were read and adopted.

Dr. Archibald Geikie, F.R.S.L. and E., President of the Geological Society of London, Director-General of the Geological Surveys of the United Kingdom, 28, Jermyn Street, London, S.W., was elected an Honorary Member of the Society.

The President delivered an Address on "Field Sports and their bearing on the National Character." (*Transactions*, Vol. VI, p. 1.)

The following gentlemen were duly elected as the Officers and Council for the ensuing year:—

President.—The Right Honourable the Earl of Clarendon.

Vice-Presidents.—F. M. Campbell, F.L.S., F.Z.S., F.R.M.S, F.E.S.; Richard B. Croft, R.N., F.L.S., F.R.M.S.; Augustus Hawks; John Hopkinson, F.L.S., F.G.S., F.R.M.S., F.R.Met.Soc.; George Rooper, F.Z.S.; Arthur Stradling, C.M.Z.S.

Treasurer.—John Weall.

Hon. Secretaries.—John Morison, M.D., D.P.H., F.G.S., and Charles Edward Shelly, B.A., M.B.

Librarian.—Upfield Green, F.G.S.

Curator.—A. E. Gibbs, F.L.S.

Other Members.—Prof. Attfield, M.A., Ph.D., F.R.S., F.I.C., F.C.S.; Percival Bosanquet; F. Haycraft Berry, M.D.; Alfred T. Brett, M.D.; Arthur M. Brown, B.A.; W. R. Carter; Alfred Eteson, M.D., M.R.C.S.; John Evans, D.C.L., LL.D., Treas. R.S., Pres. S.A., F.L.S., F.G.S.; J. W. Robins; Isaac Robinson; F. W. Silvester, F.R.Met.Soc.; Rev. E. T. Vaughan, M.A.

The thanks of the Society were accorded to Prof. Attfield and Mr. Percival Bosanquet retiring from the office of Vice-President; and to Mr. A. Barraud, Mr. A. P. Blathwayt, Mr. H. Cayley, and Mr. Daniel Hill retiring from the Council.

Report of the Council for 1889.

In presenting the 15th Annual Report, the Council of the Hertfordshire Natural History Society and Field Club has much

pleasure in stating that the Society continues to be vigorous and prosperous, the number of meetings held during 1889 being quite up to the average of former years. The attendance at the meetings, however, more especially the evening meetings, has not been so good as might be desired, but the Council earnestly hopes that all the members will do their utmost to maintain the prosperity of the Society and show their interest in the work which is being done by attending as many meetings as possible.

During the year twenty-three ordinary members have been elected, twelve members have resigned, and we have to mourn the loss of four members by death. The census of the Society at the end of the years 1888 and 1889 was:—

	1888.	1889.
Honorary Members	19	19
Life Members	41	42
Annual Subscribers	188	193
	248	254

The following papers or lectures have been read or delivered during the year:—

Jan. 22, at Watford.—Birds: their Nests and Habits; by George Rooper, F.Z.S.

Feb. 22, at Watford.—Anniversary Address—Structural Variations in the Eyes of Animals in reference to their Function; by the President, F. Maule Campbell, F.L.S., F.Z.S., F.R.M.S.

March 22, at Watford.—A Naturalist's Calendar for the South-west of Hertfordshire; by John Hopkinson, F.L.S., F.G.S., etc.

—— Report on Insects observed in Hertfordshire in 1888; by F. W. Silvester, F.R.Met.Soc.

—— Notes on Birds observed in Hertfordshire during the year 1888; by John Hopkinson, F.L.S., F.G.S., etc.

—— 25, at St. Albans.—Pre-historic Man in Britain; by Henry Hicks, M.D., F.R.S., F.G.S.

—— 29, at Hertford.—Further Reminiscences of Hertford in the 17th and 18th Centuries; by R. T. Andrews.

April 12, at Watford.—Report on the Rainfall in Hertfordshire in 1887; by John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.

—— Meteorological Observations taken at The Grange, St. Albans, during the year 1887; by John Hopkinson.

—— Climatological Observations taken in Hertfordshire in 1887; by John Hopkinson.

—— Report on Phenological Phenonema observed in Hertfordshire during the years 1887 and 1888; by John Hopkinson.

—— Notes on the Chalk Rock; by John Morison, M.D., F.G.S.

—— The Study of the Injuries and Diseases of Plants; by Alfred T. Brett, M.D.

—— Some Notes on the Lepidoptera of St. Albans and its Neighbourhood; by A. E. Gibbs, F.L.S.

—— 26, at Watford.—Metal Mining; by Upfield Green, F.G.S.

—— Report on the Rainfall in Hertfordshire in 1888; by John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.

—— Meteorological Observations taken at The Grange, St. Albans, during the year 1888; by John Hopkinson.

—— Climatological Observations taken in Hertfordshire in 1888; by John Hopkinson.

—— 27, at St. Albans.—The Hessian Fly and its Introduction into Britain; by Eleanor A. Ormerod, F.R.Met.Soc., F.E.S.

Oct. 16, at St. Albans.—Rabies and the Pasteur Institute; by John Evans, D.C.L., LL.D., Treas. R.S., Pres. S.A., etc.
Nov. 19, at Watford.—The Diseases of Plants due to Fungi; by George Massee, F.R.M.S.
Dec. 17, at Watford.—Notes on a Visit to Italy; by Alfred T. Brett, M.D.

A Bye Meeting for Microscopical study also was held at the residence of Mr. Hopkinson,—The Grange, St. Albans,—on the 15th of April, when Mr. F. M. Campbell, F.L.S., made some remarks on the eyes of insects.

The following Field Meetings were held during the year:—

April 27.—St. Stephen's, St. Albans.
May 18.—Boxmoor, Bennet's End, and Nash Mills.
—— 25.—Harpenden and Wheathampstead.
June 1.—St. Peter's, St. Albans.
—— 6.—Digswell and Hatfield.
—— 20.—Bayford and Cole Green, Hertford.
—— 22.—Bricket Wood and Munden Park.
—— 29.—Totternhoe and Ivinghoe.
July 5.—Leavesden Woods and Watford.
Oct. 19.—Bricket Wood.

The meetings on May 18 and June 29 were held in conjunction with the Geologists' Association. At the Fungus Foray, on Oct. 19, Mr. G. Massee kindly attended and named the specimens collected. Owing no doubt to the inclemency of the weather, the number of members present was extremely small.

The thanks of the Society are due, for hospitality kindly afforded at the field meetings, to the Misses Ormerod, Torrington House, St. Albans; to Dr. John Evans, F.R.S., etc., Nash Mills, Hemel Hempstead; to Mr. Richard Gibbs, The Hollies, St. Albans; to the Hon. A. H. Holland Hibbert, Munden, Watford; and to Mr. George Rooper, Nascott House, Watford.

Four parts of the Society's 'Transactions,' containing 120 pages and one plate, have been issued during the year, and the present volume will be completed in two more parts, one containing the proceedings of the last two sessions, and the other the title page, index, etc., with the list of members as an appendix. It is also intended to issue with this part a supplement to the 'Catalogue of the Library.'

The library is in a satisfactory condition, and numerous books have been received during the past year as gifts or by exchange. The Librarian regrets to say that at present the library is not used by, and appears to be practically useless to, the great majority of the members. The Council hopes shortly to be able to issue new regulations which will facilitate the borrowing of books.

In conclusion, while thanking the Committee of the Watford Public Library for the accommodation afforded to your library and museum, the Council regrets that the Committee seems to be unable to make adequate provision for the meetings of the Society on the third Tuesday in each winter month, as originally arranged, so that in some cases it has been necessary to alter the date.

INCOME AND EXPENDITURE FOR THE YEAR ENDING 31st DECEMBER, 1889.

Dr.	£	s.	d.
To Balance from 1888	23	11	11
,, Entrance Fees	10	10	0
,, Life Compositions	30	0	0
,, Subscriptions for 1887	2	10	0
,, ,, ,, 1888	8	0	0
,, ,, ,, 1889	49	10	0
,, ,, ,, 1890	15	10	0
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Audited and found correct this 18th day of February, 1890, { THOS. J. BROAD, E. M. CHATER.

Additions to the Library in 1889.

Presented.

Title.	Donor.
Adams, F. D., and A. C. Lawson. On some Canadian Rocks containing Scapolite. (*Canadian Rec. Science* [1888].)	*Dr. F. H. Hatch.*
Ashburner, C. A. The Geologic Distribution of Natural Gas in the United States. (*Trans. Amer. Mining Engineers* [1886].)	,,
Ball, V. Further Notes on the Identification of the Animals and Plants in India which were known to the early Greek Authors. (*Proc. Royal Irish Academy*, 1887.)	,,
Barrois, C. Sur les tremblements de terre de l'Andalousie. (*Mém. Soc. des Sciences de Lisle*, 1885.)	,,
——. Note sur l'existence du genre *Oldhamia* dans les Pyrénées. (*Ann. Soc. Géol. du Nord*, 1888.)	,,
Binnie, J., and R. Kidstone. On the Occurrence of Spores in the Carboniferous Formation of Scotland. (*Proc. Royal Phys. Soc.* [*Edinb.*], 1886.)	,,
Blake, J. H. On the Age and Relation of the so-called "Forest-Bed" of the Norfolk and Suffolk Coast. (*Proc. Norwich Geol. Soc.* 1880.)	,,
Bonney, Prof. T. G. Observations on the Rounding of Pebbles by Alpine Rivers. (*Geol. Mag.* 1888.)	,,
——. The Foundation-Stones of the Earth's Crust. Address at Bath Meeting of Brit. Assoc. 1888.	,,
British Association for the Advancement of Science. Report, 1888. 8vo. London, 1889.	*The Association.*
Cooke, M. C. (Ed.) Grevillea. Vol. xvii, Nos. 83–86. 8vo. London, 1889.	*The Editor.*
Cross, W. The Cimarron Land-slide, July, 1886. (*Proc. Colorado Sci. Soc.* 1886.)	*Dr. F. H. Hatch.*
Dawkins, Prof. Boyd. On some Deposits of Apatite near Ottawa, Canada. (*Trans. Manchester Geol. Soc.* [1885].)	,,
Diller, J. S. Notes on the Geology of the Troad. (*Quart. Journ. Geol. Soc.* 1883.)	,,
Goodchild, J. G. Observations upon the Stratigraphical Relations of the Skiddaw Slates. (*Proc. Geol. Assoc.* [1886].)	,,
Green, Prof. A. H. A Contribution to the Geology and Physical Geography of the Cape Colony. (*Quart. Journ. Geol. Soc.* 1888.)	,,
Groom, T. T. On some New Features in *Pelanechinus corallinus*. (*Ib.* 1887.)	,,
Grove, W. B. A Synopsis of the Bacteria and Yeast Fungi. 8vo. London, 1884.	*Mr. R. B. Croft.*
Hind, J. R. An Introduction to Astronomy. 3rd ed. 8vo. London, 1863.	*Mr. J. Hopkinson.*
Houghton, Rev. W. Sketches of British Insects. 8vo. London, 1888.	,,
Jennings, A. V. Note on the Orbitoidal Limestone of North Borneo. (*Geol. Mag.* 1888.)	*Dr. F. H. Hatch.*
Jones, Prof. T. Rupert, and W. Whitaker. On the Chalk, Sands, and Clays exposed at Shaw Hill, near Newbury. (*Trans. Newbury District Field-Club*, 1888.)	*The Authors.*
Kilroe, J. R. Directions of Ice-flow in the North of Ireland. (*Quart. Journ. Geol. Soc.* 1888.)	*Dr. F. H. Hatch.*

Title.	Donor.
Kinahan, G. H. Notes on Metamorphic Ingenite [intrusive] Rocks. (*Journ. Royal Geol. Soc. Ireland*, 1870.) .	,,
——. The Laurentian Rocks and Metamorphism. (*Proc. Edinb. Geol. Soc.* 1884.)	,,
Macgillivray, W. A History of the Molluscous Animals of Scotland. 12mo. London, 1843. . . .	*Mr. J. Hopkinson.*
McNab, W. R. Botany. 2nd ed. 16mo. London, 1879.	*Mr. R. B. Croft.*
Newton, E. T. On the Remains of Fishes from the Keuper of Warwick and Nottingham. (*Quart. Journ. Geol. Soc.* 1887.)	*Dr. F. H. Hatch.*
——. Notes on Pterodactyles. (*Proc. Geol. Assoc.* [1888].)	,,
——. On the Skull, etc., of a New Species of Pterosaurian from the Upper Lias near Whitby, Yorks. (*Phil. Trans. Royal Soc.* 1888.)	,,
——. Description of a New Species of Clupea (*C. vectensis*) from Oligocene Strata in the Isle of Wight. (*Quart. Journ. Geol. Soc.* 1889.)	,,
Nicholson, Prof. H. A. A Monograph of the British Stromatoporoids. Genera IIntroduction. 4to. London, 1885. (*Pal. Soc.*)	,,
O'Reilly, Prof. J. P. On the Directions of the Main Lines of Jointing observable in the Rocks about the Bay of Dublin. (*Proc. Royal Irish Academy*,—part 1, 1880 ; part 2, 1884.)	,,
——. On the Antipodal Relations of the New Zealand Earthquake district . . . with that of Andalucia . . . (*Proc. Royal Dublin Soc.* 1887.)	,,
——. . . . Prismatic Forms of a Group of Columnar Basalts, Giant's Causeway. (*Trans. Royal Irish Academy*, 1879.)	,,
Postlethwaite, J., and J. G. Goodchild. On some Trilobites from the Skiddaw Slates. (*Proc. Geol. Assoc.* [1886].)	,,
Ramsay, Prof. A. On the River-courses of England and Wales. (*Quart. Journ. Geol. Soc.* 1872.) . . .	*Mr. W. Whitaker.*
——. How Anglesey became an Island. (*Ib.* 1876.) .	,,
Rhind, W. The Geology of Scotland and its Islands. 8vo. Edinburgh, 1842.	*Mr. J. Hopkinson.*
Roscoe, H. E. Chemistry. 5th ed. 16mo. London, 1876.	*Mr. R. B. Croft.*
Sollas, Prof. W. J. On a Specimen of Slate from Bray-Head, traversed by the structure known as *Oldhamia radiata*. (*Proc. Royal Dublin Soc.* [1877].) . .	*Dr. F. H. Hatch.*
Sullivan, W. K., and J. P. O'Reilly. Note on the great Dolomite Bed of the North of Spain. (*Proc. Royal Irish Academy*, 1871.)	,,
Symons, J. G. Sunshine. (*Quart. Record Royal Botanic Soc.* 1885.)	*The Author.*
——. On the Proceedings of the International Congress of Hydrology and Climatology at Biarritz, Oct. 1866. (*Quart. Journ. R. Met. Soc.* 1887.)	,,
——. (Ed.) Monthly Meteorological Magazine. Vol. xxiv. 8vo. London, 1889.	*The Editor.*
Vaisey, J. R. On the Absorption of Water and its Relation to the Constitution of the Cell-wall in Mosses. (*Ann. Bot.* 1887.)	*The Author.*
——. On *Catherinea lateralis*, Vaizey, a new British Moss. (*Ann. Bot.* 1888.)	,,
——. On the Anatomy and Development of the Sporangium of the Mosses. (*Journ. Linn. Soc., Bot.*, 1888.) .	,,

Title.	Donor.
Van den Broeck, E., and A. Rutot. Un nouvel appareil portatif de Sondage. (*Bull. Soc. Belge de Géologie*, 1888.)	*Dr. F. H. Hatch.*
Whitaker, W., and W. W. Watts. List of Works on the Geology, Mineralogy, and Palæontology of Shropshire, 1712–1887. (*Trans. Shropshire Arch. and N. H. Soc.* 1889.)	*The Authors.*
Worth, R. N. The Limestones of the Plymouth District. (*Trans. Devon Assoc.* 1888.)	*Dr. F. H. Hatch.*
Woodward, H. B. The Geology of England and Wales. 8vo. London, 1876.	*Mr. J. Hopkinson.*

Received in Exchange.

American Museum of Natural History. Bulletin. Vol. ii, No. 2. 8vo. New York, 1889.

Belfast Naturalists' Field Club. Annual Report and Proceedings. Series 2, vol. iii, part 1. 8vo. Belfast, 1888.

Bristol Naturalists' Society. Proceedings. Vol. vi, part 1. 8vo. Bristol, 1889.

Conchology, Journal of. Vol. vi, Nos. 1–4. 8vo. Leeds, 1889.

Costa Rica. Anales del Museo National. Tomo i. 8vo. San José, 1888.

Edinburgh Geological Society. Transactions. Vol. v, part 4. 8vo. Edinburgh, 1888.

———. Royal Physical Society. Proceedings. Session 1888–89. 8vo. Edinburgh, 1889.

Essex Field Club. Essex Naturalist. Vol. ii, Nos. 9–12; vol. iii, Nos. 1–6. 8vo. Buckhurst Hill, 1889.

Glasgow, Geological Society of. Transactions. Vol. viii, part 2. 8vo. Glasgow, 1888.

———, Philosophical Society of. Proceedings. Vol. xix. 8vo. Glasgow, 1888.

Liverpool Science Students' Association. Annual Report for 1887–88. 8vo. Liverpool, 1888.

London, Geological Society of. Abstracts of the Proceedings, Session 1888–89. 8vo. London, 1889.

———. Geologists' Association. Proceedings. Vol. x, No. 9; vol. xi, Nos. 1–5. 8vo. London, 1889.

———. Quekett Microscopical Club. Journal. Series 2, vol. iii, Nos. 23, 24; vol. iv, No. 25. 8vo. London, 1889.

———. Royal Meteorological Society. Quarterly Journal. Vol. xiv, No. 68; vol. xv, Nos. 69–71. 8vo. London, 1888–89.

———. ———. The Meteorological Record. Vol. viii, Nos. 29–32; vol. ix, No. 33. 8vo. London, 1888–89.

———. Royal Microscopical Society. Journal. Nos. 68–70. 8vo. London, 1889.

Manchester Geological Society. Transactions. Vol. xx, parts 1–13. 8vo. Manchester, 1888–89.

———. Literary and Philosophical Society. Memoirs. Series 4, vols. i, ii. 8vo. London, 1888-89.

Marlborough College Natural History Society. Report for 1888. No. 37. 8vo. Marlborough, 1889.

Middlesex, County of, Natural History and Science Society. Session 1888–89. 8vo. London, 1889.

Midland Naturalist. Vol. xii. 8vo. Birmingham, 1889.

Naturalist. New Series, vol. xiv. 8vo. Leeds, 1889.

New York Academy of Sciences. Transactions. Vol. viii, Nos. 1–4. 8vo. New York, 1888–89.

New York State Museum of Natural History. 42nd Annual Report, for 1888. 8vo. Albany, 1889.
Rugby School Natural History Society. Report for 1888. 8vo. Rugby, 1889.
Selborne Magazine. Vol. ii, Nos. 13, 14. 8vo. London, 1889.
Somersetshire Archæological and Natural History Society. Proceedings. New Series, vol. xiv. 8vo. Taunton, 1889.
United States Geological Survey. Monographs. Vol. xii. Geology of the Mining Industry of Leadville, Colorado, with Atlas. By S. F. Emmons. 4to. Washington, 1886.
————. ————. Vol. xiii. Geology of the Quicksilver Deposits of the Pacific Slope, with an Atlas. By G. F. Becker. *Ib.* 1888.
————. Bulletin. Nos. 40–47. 8vo. Washington, 1887–88.
————. Mineral Resources of the United States . . . 1887. By R. T. Day. *Ib.* 1888.
Warwickshire Naturalists' Field Club. 33rd Annual Report, for 1888. 8vo. Warwick [1889].
Yorkshire Geological and Polytechnic Society. Proceedings. New Series, vol. xi, part 1. 8vo. Halifax, 1889.

Purchased.

Botany, Journal of. New Series, vol. xviii. 8vo. London, 1889.
Buckler, W. The Larvæ of the British Butterflies and Moths. Vol. iii. (*Ray Society.*) 8vo. London, 1889.
Entomologist. Vol. xxii. 8vo. London, 1889.
Geological Record for 1880-84. Vol. ii. 8vo. London, 1889.
Year-book of the Scientific and Learned Societies of Great Britain and Ireland. Sixth Annual Issue. 8vo. London, 1889.
Zoologist. 3rd Series, vol. xiii. 8vo. London, 1889.

Ordinary Meeting, 18th March, 1890, at Watford.

F. M. Campbell, Esq., F.L.S., F.Z.S., etc., Vice-President, in the Chair.

Mr. R. H. Bookey, B.A., Mr. C. J. Gilbert, F.G.S., and Mr. C. E. Jones, were elected Members of the Society.

Miss Gertrude Coles, The Shrubbery, Watford; Mr. Edward Mawley, F.R.Met.Soc., F.R.H.S., Rosebank, Berkhamsted; Mr. W. H. Syme, Ottawa House, Queen's Road, Watford; and Mr. Charles Van Raälte, Aldenham Abbey, Watford, were proposed for membership.

The following papers were read:—

1. "Meteorological Observations taken at The Grange, St. Albans, during the year 1889." By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc. (*Transactions*, Vol. VI, p. 25.)

2. "A Record of Water-level in a deep Chalk Well at Odsey Grange, Royston, 1878–1888. By H. George Fordham, F.G.S. (*Transactions*, Vol. VI, p. 31)

Professor Attfield, referring to the observation in Mr. Hopkinson's paper that the rainfall was less in 1889 than it had been for the last seven years, said that the amount of rain which last year went to feed our wells, was also lower than it had been for several

years; for, from his own record of the height of the water in his well, it appeared that a smaller amount of water was at the disposal of those who drew water from wells last year than for several years past. Usually the maximum of the rise in the wells of his neighbourhood was something over three feet, so that perhaps the water would be 3ft. 6in. higher in the wet part than in the dry part of the year. Three years ago there was a difference between the level of the water in the wells, on the weekly records of the year, between the level during the driest period and during the wettest period, of over five feet. The difference last year was under three feet, which confirmed what Mr. Hopkinson said.

Referring then to Mr. Fordham's paper, he said that the subject was one which interested him very considerably, and he had taken upon himself for the last six or seven years to make records of the height of the water in his own well, hoping some day to give the results, perhaps after ten years, as Mr. Fordham had done, in order that Watford might see where Watford is in this matter, not only in regard to the supply from the clouds, but in regard also to the stores beneath our feet.

The first remark he would like to make was that the rise and fall of the water in our wells is extremely variable, according to the position of the well, according to the soil, and to a number of other conditions. In the paper that had just been read they had heard of a difference between the maximum and minimum height in the whole year of 44ft. at Odsey Grange and 78ft. at Barley, which was very great. The variation of wells in the neighbourhood of Watford was very much the same as that in his own well, that is to say, so far as the height of the water in other wells had been taken. He had an apparatus fixed in his own well, kept in good working order and condition and checked from time to time, and he made observations every week of the year. As he had already intimated, the difference in the height of the water in his well during any one year was only a very few feet indeed, and he could say that after recording the height for six years, in no year had the variation been more than five feet—to be particular, 5·1, and the least 2·6 feet. In 1884, the difference in the height about February, when the water attains its maximum, and in November or December when it attains its minimum, was 3·6; in 1885, 2·6; in 1886, 3·5; in 1887, 5·1; in 1888, 3·4; in 1889, 2·9. Therefore, so far as his well represented the wells in the neighbourhood, Watford might rest content that there had been no very great draw on the water. The water-saturation plane of the neighbourhood varied only some three or four feet, a very inconsiderable quantity.

With regard to the question as to whether any of the big wells in the neighbourhood were interfering with the private wells, he could say that they did not interfere with them in the slightest; but then, his observations only ran back some six years. Still, during those six years there was the stated perceptible variation, though not worth mentioning, from year to year. Taking the

mean levels during the past year and each of the other five years, he got 191·2 as lowest, and 192·3 as highest above the level of the sea. He preferred to take the level from the sea, because he knew of no other satisfactory datum to work from, as the surface of the land varied so much. But they had one constant datum in the mean height of the sea, and as it sufficed in speaking of the height of mountains, so he thought it might in speaking of the height of water in wells. From the figures he had given they would see that there had not been a *mean* variation per annum of much over one foot in the height of the water in his well for some six years.

He also found, as did the author of the paper, that the general plane of saturation in the neighbourhood, into which the tube called a well dips, goes on rising until about the end of February or March, sometimes the beginning of April, and that the time at which the water is lowest is commonly October or November. Then begin the winter rains, and they go on saturating the ground, and the highest level of the water is commonly reached about March in this neighbourhood.

Another question arose, and it was one frequently asked though not touched upon by the author of the paper, as to how long it takes for the water which falls on the surface to get down to the plane of saturation. That depended upon the distance, and, for his own neighbourhood, where there were about twenty wells, the distance was 80 feet. It would be seen at once that, during the summer, the rain which falls on the surface does not get down to the stores below at all. The sun dries the surface, and the rain penetrates only a short distance, and dries out again. In January or February, however, with the amount of rain that has fallen during the earlier part of the winter, the whole of the soil down to the plane of saturation becomes wet, and a heavy rainfall will make itself felt in the rise of water below in the course of two or three hours. He did not mean to say that the rain which then falls goes down directly to the stores below; it acts according to hydraulic laws, and the water already saturating the earth is pressed down by that which falls on to the ground, and it is in that way, by the transference of water pressure through the influence of the rain then falling, and not at once by the rain itself, that the water-level is raised.

He should like to support what the author said with regard to the importance of records, particularly as to the nature of the soil and the distance from the surface to the plane of saturation. From these and other causes the variation must be very great, and therefore it is not until observations are made by one person for a number of years, and comparisons are made between the observations of different persons, that they would be able to generalise and to get an useful record of the flow and general conditions of the stores of water below, on which we all depend for our daily supply.

Prof. Attfield then briefly described his apparatus. He said that a post eight or ten feet high was fixed immediately above the well. It was surmounted by a pulley. Over the pulley passed a chain,

one end of which went down the well and terminated in a plumber's ordinary hollow ten-inch copper ball floating on the water; the other end being only a few feet long, and terminating in a counterpoise. As the water rose and fell, the chain moved up and down, and a little pointer fixed on the part of the chain opposite the post pointed to the feet and tenths of a foot marked on the post. The sea-level, or national ordnance datum, was obtained from an adjacent ordnance bench-mark conjoined with the corresponding figures on the Watford sheet of the ordnance map. He would be happy to show the simple apparatus to anybody at any time. Water flowed into his well very slowly, hence there was a temporary fall in the level after each pumping, but his household drew so small an amount that the water again reached the maximum height within 24 hours, so that records, even if he took them daily, would be thoroughly trustworthy.

Mr. S. Monckton White said that there seemed to be a difference in the different parts of the county. He had a well at St. Albans about 50 feet deep. About three years ago there was so little water in it that he had to sink an artesian well and to put in a pipe much deeper, and he had had more water in 1888 and 1889 than for the previous four years.

Dr. Brett said that observations made by Mr. George Wailes at the London Orphan Asylum showed nearly the same results as those stated by Professor Attfield. Presuming the water to be distributed in the way Stephenson stated, they might consider Odsey as being situated at the top of a cup, and Watford at the bottom. He thought therefore they might expect a greater variation in the water-level in the wells at Odsey.* The Rev. James Clutterbuck, who was the father of hydro-geology, once told him that it takes an inch of rain to saturate the ground, or, so to speak, lay the dust, after the summer.

The Chairman expressed the hope that Professor Attfield would communicate to them exact particulars as to his observations. He did not know how far they might feel the effect of the borings in the valley of the Colne, but in his neighbourhood the question was becoming rather serious, and he was not at all certain whether, if Professor Attfield's well had been in the Lea valley, he would not have found a considerable difference. He might suggest that the series of borings in the Lea valley might even affect the water-level as far as Royston. He knew several wells and even ditches that had been drained dry, and several streams that used to be water-cress beds also now dry, and the only cause that he could assign for it was the taking of the water for the supply of London.

* The true explanation of the greater variation in the water-level in the Chalk at a distance from a river than close to one, has been pointed out by Dr. John Evans. It is that the surface of the saturated portion of the Chalk is an inclined plane sloping to the nearest point of discharge. By the side of a stream with springs rising in its bed the variation in the water-level will be practically *nil*, but the difference between the level in dry and wet seasons will increase with the distance from the point of discharge.—Ed.

If in the neighbourhood of Watford they had managed to prevent London from taking their water, those on the other side of the county were subject to the New River Company sinking wells along their property, and really draining the Lea Valley of water, and it could refuse to give them a single drop. They might perhaps have to come to Watford with their hats in their hands and ask them to give them some. Their wells were very much lower than they were some years ago. The New River Company was sinking very deep wells, the population of London was rapidly increasing, the ordinary wells in the neighbourhood were supplied with surface-water, and he feared that the deepest would be affected and the shallowest would be dried, and that there would be a scarcity of water all along the valley.

3. "Note on the Discovery of *Ornix fagivora* in Hertfordshire." By A. F. Griffith, M.A. (*Transactions*, Vol. VI, p. 75.)

4. "The Swan." By S. Monckton White.

5. "Note on a White Stoat at Hoddesdon." By F. M. Campbell, F.L.S., F.Z.S., etc. (*Transactions*, Vol. VI, p. 76.)

Several stuffed specimens of the stoat varying considerably in colour, and also the white one referred to in his paper, were exhibited by Mr. Campbell.

Ordinary Meeting, 16th April, 1890, at St. Albans.

A. E. Gibbs, Esq., F.L.S., in the Chair.

Mrs. Acworth, The Hook, Northaw, Potter's Bar; Mr. Charles H. Ashdown, F.R.G.S., Belmont, St. Albans; the Rev. W. D. Fenning, M.A., Haileybury College, Hertford; and Mr. H. J. Salisbury, Alma Road, St. Albans, were proposed for membership of the Society.

The following papers were read:—

1. "On Local Scientific Investigation in connection with Committees of the British Association." By John Hopkinson, F.L.S., F.G.S., etc. (*Transactions*, Vol. VI, p. 37.)

2. "On Geological Photography in Hertfordshire." By John Hopkinson, F.L.S., F.G.S., etc. (*Transactions*, Vol. VI, p. 49.)

3. "The Art of Photography." By S. Monckton White.

Mr. White said that he believed it was the intention of the Hertfordshire Natural History Society to introduce the art of photography to the consideration of its members, and having started a camera of his own within the last twelve months, it had occurred to him what a boon it would be, and how much it would add to the interest of the Society's field meetings, if some of the members were able to bring home with them a memento of their day's outing, in the shape of a photograph of some place of interest, a ruin, church, or pretty piece of scenery; for an amateur had this advantage—he could roam at his pleasure and photograph

anything of which he wished to have a memento, whereas the professional's time would only allow him to take set pieces.

In choosing apparatus the amateur should eschew all cheap sets (for their purchase would only bring disappointment), and furnish himself with a good apparatus, his wants, of course, being regulated by the length of his purse. For a ten-pound note, or thereabouts, he could obtain a camera, lens, and stand, which would produce for him pictures which he need not be ashamed to show to his friends. The size known as half-plate ($6\frac{1}{2}$ inches by $4\frac{3}{4}$ inches) was a suitable one for a beginner, for with larger sizes the whole process was more troublesome and expensive. The camera should be rigid when set up on the stand, so that it would not vibrate with every breeze. In addition to the camera and stand there would be required a focussing-cloth, lens, stops or diaphragms, and cap.

The plates having been placed in the double-back, in the dark room, the camera was ready for action, and must be placed before the object, care being taken to get at the distance which would give the best effect. After the view had been focussed upon the ground glass screen, and a suitable stop inserted in order to modify the light and sharpen the details, the cap should be put on the lens, the ground glass thrown back, and the frame containing the plates placed in the groove provided for it, the focussing-cloth being used to protect it from the light. After drawing the shutter of the frame, the gelatine plate would be ready for exposure, and by removing the cap from the lens the light would act upon it. After the exposure, the cap should be replaced and the shutter closed. The double-back had then to be removed, wrapped in the focussing-cloth, and placed in some secure place until the plates could be developed.

Correct exposure he considered to be the most important part of the process of photography, and it was a thing which could only be learned by constant practice and attention to details. It was quite impossible to fix definitely the length of time during which the cap should be removed from the lens, as so much depended on the intensity of the light, the nature of the object, the aspect, plates, lens, and diaphragm. The old adage, *Experientia docet*, could not be more aptly quoted than in connection with this question of exposure.

With regard to the lens, he would recommend the rectilinear, which gives lines free from distortion, and which would do for portraiture, landscape, architecture, copying, and enlarging. He preferred the "Ilford Rapid" plate, but he would advise the members to find out which class or make they preferred, and to keep to it, because changing about often brought one to grief.

For developing the exposed plate a dark room was required; it should only be lighted by red light and not a ray of white light should be allowed to enter. The next thing was the choice of a developer, of which there were several kinds. He used a solution called Edward's Pyro Developer. The plate should be rinsed in water, the solution poured quickly over it, and the tray containing

it should be gently rocked to keep the solution in motion. The object would be perceived gradually appearing on the plate, which, when fully developed, must be rinsed in clean water and placed in a solution of hyposulphite of soda. In a few minutes the whiteness seen on the back of the plate would disappear and the picture would be "fixed." After another rinse in water the negative would be completed, and might be taken to the daylight and examined at leisure. Before it was put into a rack to dry, it was advisable that it should remain for one hour in running water. The negative being dry, then came the printing process, a work in which amateurs as a rule did not excel, for it required much patience, and comprised several operations full of detail, each of which must have very careful attention.

The prints, having been obtained, should be rinsed, and then placed in the toning-dish. Emerging from the toning-dish, they should receive another rinse, and be fixed by being placed in a solution of hyposulphite of soda and ammonia. In about a quarter of an hour the print would be fixed, and should then be allowed to remain in running water for four or five hours and afterwards dried on blotting-paper. The final process was that of mounting.

Mr. White also dealt with the subject of varnishing negatives, photographing by magnesium light, and the process of printing on platinotype paper. In conclusion, he expressed a hope that his paper might be the means of enrolling some amateur photographers as members of the Society, and that the pleasure of the summer excursions might be enhanced by the practice of this engaging art, and the interest of the winter meetings by its theory.

The following geological photographs (whole-plate), kindly lent by Mr. Osmund W. Jeffs, Secretary of the British Association Committee on Geological Photography, were exhibited by Mr. Hopkinson in illustration of his paper :—

Four views in Storeton Quarry, Cheshire, two of them showing footprint-bed in Keuper Sandstone. Junction of Keuper and Bunter Sandstone at West Kirby, Cheshire. Open face of fault at Calday Grange, West Kirby. Junction of (?) Bunter and Keuper Sandstone at Hilbre Island, River Dee, Cheshire. Two views of conglomerate-bed (pebble-bed of Geological Survey), (?) Bunter, Middle Island, Hilbre. Current-bedding in Keuper Sandstone, Wallasey, Cheshire. Two views of the "Calderstones," Woottton, near Liverpool. Anticlinal in Carboniferous Limestone, Draughton, near Skipton, Yorks. Two views of contorted strata at Draughton. Scarlett Point, Isle of Man; and glaciated surface of Carboniferous Limestone, Port St. Mary, Isle of Man. Stack of Mharagast, Isle of Rum. Flagstone, East Cliff, Holborn Head, Caithness. Stack of contorted gneiss, Whitenhead, Sutherland.

Mr. Monckton White also exhibited a large collection of photographs, including several taken by himself, and his camera and other apparatus referred to in his paper.

Field Meeting, 19th April, 1890.

NORTH MIMMS, HATFIELD.

This was a combined meeting of the Hertfordshire Natural History Society and the Geologists' Association of London.

The party assembled at Potter's Bar Station, and, under the guidance of Mr. Upfield Green, F.G.S., walked by way of Mimms Hall and Warren Gate to Potterells Park. From Mimms Hall the walk was by the side of the bourne which drains the London Clay area on the south. In Potterells Park are some large cavities or "Swallow-holes," through which the water generally descends into the Chalk, but upon this occasion the bourne was dry, and the stream did not flow into the holes. Assembled on the slope of the dell in which the swallow-holes are situated, Mr. Upfield Green alluded to the loss the party sustained by the absence, through an accident, of Mr. Hopkinson, who was to have acted as conductor. He had, however, sent the following paper, which Mr. Green read, on "The River Colne and the Swallow-holes at Potterells."

"It is a very general rule that the name of a river is retained to the head of its largest branch, which, bringing down the greatest quantity of water, drains the largest area. If there is a deviation from this rule, it is when the largest stream takes an abrupt turn, the name then sometimes being carried by a smaller stream which takes a more direct course. It has been pointed out that to comply with this rule the name Colne ought to have been carried up to the stream known as the Ver, for not only is the Ver a much larger river than the Colne at the junction of the two streams, but it also maintains the general direction of the united stream quite as much as does the Colne. That the Colne, above here, was a smaller river than its tributary the Ver, was remarked upon so far back as the year 1700, for Chauncy, in his 'Historical Antiquities of Hertfordshire,' says: 'The Colne, which springs forth near Tittenhanger, then passeth the road near Colney Street, and, running above two miles in length, meets the Verlume (Ver) near Park Street, but though the Verlume is much the greater stream, yet the Colne usurps the glory of her own name, and floweth thence to Watford.'

"I am not aware that any explanation of this anomaly has yet been offered, but I think that we may possibly have a key to it at this spot. The swallow-holes here absorb most of the drainage of about 40 square miles, the stream from the south draining about 35 square miles, and that from the north about five. The whole of the London Clay area between Bell Bar, Northaw, Potter's Bar, Chipping Barnet, Barnet Gate, Green Street, Shenley, Ridge Hill, and North Mimms, is drained by the southern stream; while the northern stream drains the area between North Mimms, Dulsham Green, Bell Bar, and Brockman Park. A glance at a geological map will show that these streams and their tributaries have materially altered the configuration of the country, the northern stream, which has several small tributaries flowing from under the glacial gravel between Hatfield Park and Bell Bar, having almost com-

pletely cut through the Tertiaries so as very nearly to cut off the Reading Beds from the main mass and form of them an 'outlier' between Hatfield and North Mimms; and the southern stream and one of its branches having nearly made an outlier of the London Clay and Reading Beds between North and South Mimms and Shenley.

"Let us consider one of the results of this. These rivers, at one time flowing throughout their entire course over impervious London Clay, have now cut down their beds to the Chalk for much the greater part of their course, and when this is the case we know that water no longer flows on the surface unless the plane of saturation in the Chalk comes to the surface. The Chalk, being permeable, absorbs the water and becomes saturated, the plane of saturation rising slightly from the valleys towards the hills. But the Chalk absorbs water very slowly, and therefore, after heavy rain, water may flow for a time in a Chalk river-bed when the plane of saturation does not come up to this bed. Some of the water is thus gradually, imperceptibly, sinking into the Chalk while there is sufficient to spare to form a river on the surface; but sooner or later the water will find a more rapid way into the Chalk than through mere absorption. A weak spot or fissure is met with and down sinks the water. Having once found a way, almost every drop enlarges the crevice by the mechanical removal and chemical dissolution of the chalk, and thus 'swallow-holes' appear on the surface, and 'pipes' form underground. At first there may be merely more rapid percolation, the pipe filling with gravel and sand, and the insoluble residue of the Chalk, such as flints, but in course of time a channel is sometimes formed, as in several swallow-holes here, down which the water rushes to the plane of saturation with ever-increasing volume.

"At this spot there are channels which the water has gradually made for itself down which a man might be carried. I have seen these swallow-holes when no water reached them; I have seen them when a powerful stream came from the south and rushed down them in torrents with a roar which I heard long before I could see what was its cause; and I have seen them, or rather the spot where we know they are, when they were covered by a sheet of water forming a peaceful lake into which streams flowed from north and south, and out of which a stream flowed on through Mimms Park and into the permanent river of the Colne. Then doubtless the plane of saturation in the Chalk was raised to above the apertures of the swallow-holes, in fact to the level of the water in the lake.

"I do not know when these rivers received their names, but the Ver, or Verlam, must have been so named when the Romans invaded Britain and attacked the old British town of Verulam, and the Colne was probably named before the Ver. Even if we can only date back the naming of these rivers about 2000 years, almost every day during that period the Colne and its tributaries above this point have been cutting their beds through the

Tertiaries into the Chalk, and so lessening the volume of water they convey above the surface, and these swallow-holes have been enlarging. It may be asked: Has not the Ver been doing the same? It has not, for nowhere is it a stream flowing over clay; it is a Chalk stream from its source to its junction with the Colne, and it is not subject to floods as is the Colne. It is not intended that it should be inferred from this that the Ver is not now decreasing in volume to some slight extent, for there is evidence that it is doing so, probably owing to the lowering of the plane of saturation of the Chalk, but instead of its waters being conveyed away through swallow-holes, its volume is increased by springs in its bed.

"But this is not all. Lower down the valley, just above its junction with the Ver, the Colne must at one time have had its waters considerably augmented by a stream flowing out of Elstree Reservoir. In this stream there are now swallow-holes which usually take all the water which drains the London Clay area between Shenley, Elstree, Stanmore Heath, Letchmoor Heath, and Radlett. This water is thus conveyed underground, and when it is required the swallow-holes have to be plugged. Moreover, along the margin where the Tertiaries cease to cover the Chalk, there are several other swallow-holes, not now in the bed of any stream, but, nevertheless, they convey away water which may once have formed streams flowing into the upper part of the Colne. We may thus add about 20 square miles to the 40 we had before, making an area of about 60 square miles in the upper basin of the Colne, the rain falling on which is now usually absorbed by swallow-holes and conveyed into the underground Chalk reservoir, but long ago formed streams which must have augmented the volume of the Colne above its junction with the Ver. Much of this water may now find its way into the Colne below the junction of the two streams; the springs at Otterspool, near Watford, which are known to many of the members of the two Societies here present, are probably partly fed by it. Some of it is doubtless pumped up from the Chalk at waterworks and in numerous wells in Watford and Rickmansworth and their vicinity; and some probably flows on in the Chalk towards the valley of the Thames, or, following the plane of dip in beds of flints in a south-easterly direction, is intercepted at the deep borings of the New River Company in the valley of the Lea.

"I think it will be evident that the Colne must at some former period have been, above its junction with the Ver, a much larger stream than it is now, while we have no reason to suppose that the volume of the Ver has very materially decreased; and to this fact it seems likely to be due that the name of the Colne pertains to that which is now much the smaller stream. We have seen that it was smaller in Chauncy's time, nearly two centuries ago, but I think we have some evidence that the bed of the Colne was not, as it now is, usually dry through Mimms Park a century before then, when the fine mansion, known as North Mimms Place, was built. This

has now, from its principal front, throughout the whole of the time during which residence in a country house is most enjoyable—the later spring, the summer, and autumn months—a view of a dry river-bed, in some places deep and wide ; and I cannot imagine the house to have been built, situated as it is nearly facing the north, except that it might overlook a flowing river.

"The extent of variation of the source of the Colne is about 15 miles, from near Barnet Gate, midway between Chipping Barnet and Elstree, to a few field-lengths above Colney Street, where I have seen the river rise in a very dry year."

From Potterells Park a pleasant route was followed, Hatfield being reached at about six o'clock. Tea was partaken of at the Temperance Hotel, after which Mr. Thomas Leighton, on behalf of the Geologists' Association, proposed, and Mr. A. E. Gibbs, on behalf of the Hertfordshire Society, seconded, a vote of thanks to Mr. Green for conducting the party, and to Mr. Hopkinson for his paper.

Mr. Henry Lewis contributes the following notes on the birds observed in the course of the walk :—Swallows: one seen. Reed-bunting: handsome male in full nuptial dress. A redbreast was heard indulging in some of the black-cap's sweet wild notes, and a song-thrush appeared in a similar character. This bird was also varying its melodious song by mimicking some of the blackbird's notes, and appeared to be making the same daring attempts at the nightingale's unrivalled melody. This he (Mr. Lewis) thought worthy of notice, but he refrained from any positive assertion, and merely referred to the incident as it might lead to further investigation on this interesting subject. Pheasants were observed, and amongst them was noticed a white variety. The nightingale was heard.

Ordinary Meeting, 22nd April, 1890, at Watford.

Uffield Green, Esq., F.G.S., in the Chair.

Mrs. Ackworth, Mr. C. H. Ashdown, Miss Gertrude Coles, the Rev. W. D. Fenning, M.A., Mr. Edward Mawley, F.R.Met.Soc., F.R.H.S., Mr. H. J. Salisbury, Mr. W. H. Syme, and Mr. Charles Van Raälte, were elected Members of the Society.

Mr. Stephen Salter, Hills Court, Watford, and Mr. H. Morten Turner, Clarendon Road, Watford, were proposed for membership.

The following papers were read :—

1. "Report on the Rainfall in Hertfordshire in 1889." By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc. (*Transactions*, Vol. VI, p. 65.)

2. "Temperature and Rainfall at Hitchin, 1850–89." By John Hopkinson. (*Transactions*, Vol. VI, p. 72.)

3. "Some Hertfordshire Well-sections.—Second Paper." By W. Whitaker, B.A., F.R.S., F.G.S., Assoc. Inst. C.E. (*Transactions* Vol. VI, p. 53.)

4. "Hertfordshire Plant-Records, 1886–89." By John Hopkinson, F.L.S., etc. (*Transactions*, Vol. VI, p. 74.)

Mr. Henry Lewis made some remarks on the hybernation of swallows. Mr. Sexton had, he said, informed him that at Apsley Mills a swallow was seen on several occasions during the winter months; also that it inhabited the dark loft over the mill, and lived through the winter to join its fellows in the spring. Mr. Sexton saw the swallow himself, and several workmen could corroborate his statement. The drawback, however, to this statement was that this happened from ten to fifteen years ago. But it might perhaps throw a little light on the hybernation of the swallow. It was the only observation he had ever known of swallows being induced to remain and join their companions in the spring. Swallows had been noticed in every one of the winter months. The 'Field' lately contained a notice of their having been seen in January and February of this year.

Field Meeting, 10th May, 1890.
REDBOURN AND HARPENDEN.

Leaving St. Albans at 2.26, the party travelled by rail to Redbourn. After a pleasant walk across the Common, where the fine avenue of elm trees was admired, Foster's Farm was visited, and Mr. George Farr kindly accompanied the members in their inspection of the ancient earthwork known as Arbury Banks.

Mr. A. E. Gibbs, F.L.S., who acted as director of the meeting, pointed out that very little was known about the encampment. It was oval in shape, enclosing some 20 acres, being about 460 yards long by 416 broad. In places there was a double fosse, and on the side nearest the railway there had probably been an entrance. Some questions were asked as to its age, and Mr. Gibbs stated that it was probably of British origin. Last year the Society visited Totternhoe and saw a Roman earthwork there. That, like most Roman camps, was quadrangular in shape, while this was oval, which seemed to point to its being of pre-Roman date.

After a short walk on the earthwork, the party returned to Redbourn, whence an enjoyable walk was taken by way of Rothamsted Park to Harpenden. The early foliage of the trees and the freshness of the herbage gave the country a very beautiful appearance.

At Harpenden the members of the Society and their friends were hospitably entertained at tea by Dr. McLean at The Hall, and inspected the old house and gardens.

Field Meeting, 31st May, 1890.
ROTHAMSTED, HARPENDEN.

Although only a small number of the members took part in this meeting, which was arranged to enable them to visit the laboratory and experimental grounds of Sir J. B. Lawes, at Rothamsted, Har-

penden, thanks to the courtesy of Dr. Gilbert and the generosity of Sir John, the meeting proved to be one of the most instructive and enjoyable field gatherings which have taken place for some time.

The members were first taken into the laboratory, which was built by public subscription and presented to Sir John Lawes, and here Dr. Gilbert made some very interesting remarks, taking as his text "Nitrogen in relation to Plant-life." It would be just 47 years on the morrow, Dr. Gilbert informed his audience at the outset, since he and Sir John first commenced working together, and therefore his subsequent observations were enhanced by the knowledge that they were the outcome of a ripe experience. Dr. Gilbert possesses the happy knack of imparting a great deal of information in a very short space of time, and when he concluded his lecture—for such it was—which occupied but a few minutes, the amount of ground he had covered in the field of scientific research was astonishing. In 1857 experiments were commenced to determine whether plants assimilate free or uncombined nitrogen, and also various collateral points. Plants of the graminaceous, the leguminous, and other families were operated upon, and the conclusion arrived at was that our agricultural plants do not themselves directly assimilate the free nitrogen of the air by their leaves. As to whether the free nitrogen of the atmosphere is brought into combination within the soil under the influence of micro-organisms, or other low forms, thus serving as a source of nitrogen to plants of a higher order, the results obtained seemed to indicate that there had been a gain of nitrogen beyond that supplied in the combined form in the soil and in the seed sown.

The members, having taken a hurried glance round the laboratory, with its 40,000 samples of experimentally-grown vegetable produce, animal products, ashes, and soils, and its diagrams, were conducted round the experimental grounds by Dr. Gilbert, who halted at each plot and elaborated upon the remarks previously delivered in the laboratory. In the course of their wanderings the party passed *unter den Linden* in front of Sir John's residence, Dr. Gilbert assuring his audience that the magnificent limes surpassed those which have given a name to the principal street in Berlin. Passing on, the members came to the Park, where for the past 34 years experiments have been made with different manures on permanent meadow-land. When the experiments commenced, the character of the herbage appeared uniform all over the plots, but the constant application of the same description of manure to the same plot year after year has had a wonderful effect upon the appearance of the plots and upon their botanical composition. The general result appeared to be that the more luxuriant the crop the more limited the variety of the herbage.

Dr. Gilbert next explained the experiments which were being made with leguminous plants, root crops, and potatoes, and volunteered the information, for the benefit of the ladies present, that the Irishman's favourite vegetable was best cooked in its "jacket," as it thereby retained its valuable properties.

At the conclusion of a highly interesting three hours' walk the members returned to the laboratory, on the lawn in front of which tea was awaiting them. With appetites sharpened by the afternoon's exercise, the visitors unanimously and unceremoniously, without any assistance from Dr. Gilbert, undertook an interesting practical experiment on their own account, and had the satisfaction of seeing their efforts rewarded with success. During tea Mr. Silvester rose and proposed a hearty vote of thanks to Dr. Gilbert for the instructive information he had imparted, and asked him to convey the thanks of the members of the Society to Sir John Lawes for his kindness in providing the tea. Mr. A. M. Brown, of Tring, seconded the vote of thanks, and Dr. Gilbert suitably replied.

Field Meeting, 14th June, 1890.

THE BARTON HILLS.

The party, which was not a very large one, journeyed from St. Albans to Harlington by railway.

Shortly after leaving the station, the Manor House, a mediæval structure, was visited. It is said that John Bunyan was brought here after having been captured in the neighbourhood, and that a trial took place in the house before "the Glorious Dreamer" was sent to Bedford. A small dark compartment in the roof was shown as the chamber in which Bunyan was imprisoned.

The walk being resumed, led through picturesque Bedfordshire villages and hamlets along the Gault plain at the foot of the Chalk hills. Luncheon was partaken of in a field, and then the party walked through some pretty woodland glades by the side of a clear stream flowing from the Chalk, and along meadow-paths to the Vicarage at Barton-in-the-Clay, the charming gardens of which were visited. The Chalk escarpment was then ascended to a spot where the curious fly-orchis grows. The Barton springs next attracted attention, a considerable body of water flowing from the hill side at the bottom of a picturesque "coombe" or valley. The view from the top of the escarpment was very fine, away in the distance being Wrest Park House, at the foot of the downs the village of Barton, while the nearer prospect was composed of the Chalk hills with their rounded contours.

Ravensburgh Castle, an earthwork said to have been a Roman summer camp, was next visited; and, assembled at the foot of the earthwork, Mr. J. Saunders, of Luton, made a few remarks on the geology of the neighbourhood. He said it was generally stated that the springs issued from the hills just above the hard bed of Totternhoe Stone, but observation led him to conclude that this was not the case, but that the water issued from the top of the Chalk Marl, which was a clayey, impervious bed, through which water could not penetrate. Referring to the strata in ascending order, he pointed out that towards the north near Ampthill they had an outcrop of the Oxford Clay; above that was the Lower Greensand; at Harlington they found the Gault; and at the foot

of the hills was the Chalk Marl. Then towards the bottom of the escarpment the Totternhoe Stone was to be found; the slopes consisted of Grey Chalk; the Melbourn Rock cropped out just below the summits; and the plateau above consisted of the rocky and shelly chalk of the *Rhynchonella Cuvieri* zone.

On the plateau were some patches of glacial gravel, and Mr. A. E. Gibbs pointed out that these gravel beds contained fossils which belonged to the Gault, and which had been re-deposited in their present position.

The members then proceeded to Barton Hills Farm, where an *al fresco* tea was partaken of. They subsequently drove to Luton, and before leaving for home visited the fine ornithological collection of Mr. Cane, in Wellington Street. Much admiration was expressed at the splendidly-mounted specimens of birds and other animals, and a vote of thanks was passed to Mr. Cane for throwing open his museum for inspection. A similar vote was accorded to Mr. W. Hare, who acted as leader of the party, and had made all the necessary arrangements. During the day no less than seven species of orchids, including the fly and the bee, were found, as well as a number of other uncommon plants.

The orchids were as follows:—*Listera ovata*, R. Br., *Orchis ustulata*, L., *O. latifolia*, L., *O. maculata*, L., *Gymnadenia conopsea*, R. Br., *Ophrys apifera*, Huds., and *O. muscifera*, Huds. The other more interesting plants were *Ajuga chamæpitys*, Schreb. (ground-pine), *Crepis taraxacifolia*, Thuill., and a peculiar monstrous form of *Plantago lanceolata*, L.

Field Meeting, 19th July, 1890.

SHENLEY AND RADLETT.

In July, 1884, the members of the Hertfordshire Natural History Society and of the Geologists' Association of London paid a visit to Newberries, under the guidance of Mr. Hopkinson, to inspect a pit in which the Hertfordshire conglomerate was believed to occur *in situ*. After a lapse of six years the same spot was now again visited under the direction of Mr. Upfield Green, and in anticipation of the event the pit had been further developed and opened up, by the kindness of Mr. Henry Lubbock, the present owner of the estate. The bed previously seen was now found to consist of large and small blocks of conglomerate embedded in clay, overlying a stratum of black-coated pebbles of irregular size, and much intermingled with sand and clay.

The Director, referring to a plan and sections of the locality on a large scale, pointed out that the spot on which they were then standing should be occupied by the upper beds of the Woolwich and Reading Series, and that the basement-bed, if existing at all near that spot, should be at some distance further north. He, however, believed that the surface no longer consisted of these beds *in situ*, but that they had been re-arranged and intermixed with detritus of the London Clay washed down from the higher ground

lying to the south by the stream now flowing at a much lower level. Referring to specimens he had brought with him, collected from various parts of this county and Buckinghamshire, he pointed out that only here and near North Mimms was the pudding-stone found in immediate contiguity to the Reading Beds, while elsewhere extending beyond Missenden in the west it was found embedded in drift gravels, clay, or clay-with-flints. With regard to the conglomerate itself, great variation in the composition of the inclusions and the matrix was shown. Some specimens partook more of the nature of a breccia than a conglomerate, and while the inclusions in some, notably those under review, consisted almost entirely of pebbles of the Reading Beds, in others angular and subangular fragments of flint and chert, with rolled pebbles of chalk and clay silicified, were largely present.

Passing on to the question as to the origin and mode of formation of these blocks, the Director expressed the opinion that they were of fluviatile origin and formed at the debouchure of streams flowing northward, which, draining the London Clay, cut through the Woolwich and Reading Beds, and deposited the detritus either in subterranean streams or in the bed of a pre-glacial river having a course parallel to and south of the Chalk escarpment. The two remaining representatives of these northern streams were the Mimms stream, flowing from South Mimms, which only after heavy rains flowed into the Colne, disappearing at other times, on reaching the Chalk, through various swallow-holes, and the Medburn stream, flowing from Aldenham Reservoir also into the Colne, the swallow-holes near Radlett, through which the greater part of the stream formerly disappeared, having now been plugged. The silica, subsequently cementing these re-arranged materials, he considered to have been derived from the decomposition of the soluble silicates of the felspathic constituents of the Glacial Drift. Time would not allow of a further development of his views on this question, but he hoped to embody them, on some future occasion, in a detailed paper on the subject.

Field Meeting, 30th July, 1890.

PARK STREET, ST. ALBANS.

On this occasion the members of the Society and their friends were invited to tea by Mr. F. W. Silvester, of Hedges, St. Albans, and also to visit the Frogmore Flower Show held at his residence.

The proposed walk by the River Ver, announced in the circular for this meeting, was abandoned, and the members, numbering about thirty, went direct to the Flower Show, where several collections of wild flowers and grasses from the neighbourhood, gathered and arranged by children, and a fine collection of named specimens of herbaceous plants used in the preparation of medicine, shown by Mrs. Baldwin, Munden Lodge, Bricket Wood, attracted special attention.

Field Meeting, 8th October, 1890.

HATFIELD PARK.

Having obtained permission from the Marquis of Salisbury to wander at will in his park and in the grounds surrounding Hatfield House, the members, but few in number, first crossed the park from the entrance opposite the station to the woods beyond the Vineyard, and made a most exhaustive search for fungi, this being the annual Fungus Foray. Their efforts, however, were not rewarded with much success, for, owing to the dry autumnal weather, these moisture-loving plants were here as elsewhere unusually scarce. Several conspicuous and usually common species were now conspicuous only by their absence, but on the other hand a considerable addition was made to the Hertfordshire list, and a few rare species were found, including one which had only once before been seen in Britain, as mentioned below.

Phallus impudicus made known its whereabouts by its smell, but the specimen was so hidden in shrubby undergrowth that the search for it was almost given up before it was espied.

Leaving these woods, the members crossed the park towards the house, and met with rather better success in the beautifully-timbered private grounds adjoining it. But the shades of evening soon were falling, and it became a difficult matter to detect the minuter species under the trees and amidst the fallen leaves, so at dusk this happy hunting-ground was abandoned, and, after a walk through the more trim and stately gardens, the park was left by the door in the picturesque old gate-house near the Church.

Mr. George Massee accompanied the party and has furnished the following list of species found; those now first recorded for Hertfordshire having an asterisk affixed, and the rarer species a dagger.

Hymenomycetes.

Agaricus (Amanita) mappa, *Batsch.*
,, (Lepiota) muscarius, *L.*
,, ,, granulosus, *Batsch.*
,, (Armillaria) melleus, *Vahl.*
,, (Tricholoma) terreus, *Schæf.**
,, ,, personatus, *Fr.*
,, ,, saponaceus, *Fr.*
,, (Clitocybe) fragrans, *Sow.*
,, ,, odorus, *Bull.*
,, ,, phyllophilus, *Pers.*
,, ,, infundibuliformis, *Schwein.*
,, (Collybia) maculatus, *A. and S.**
,, ,, esculentus, *Wulf.*
,, ,, rancidus, *Fr.*
,, ,, radicatus, *Rehl.*
,, (Mycena) galericulatus, *Scop.*
,, ,, epipterygius, *Scop.*
,, ,, purus, *Pers.*
,, ,, hæmatopus, *Pers.*
,, ,, filopes, *Bull.*
,, (Omphalia) rusticus, *Fr.**
Agaricus (Pluteus) cervinus, *Schæff.*
,, ,, chrysophæus, *Schæf.**
,, (Entoloma) sinuatus, *Fr.*
,, (Pholiota) squarrosus, *Muell.*
,, ,, adiposus, *Fr.**
,, (Hebeloma) spumosus, *Fr.**
,, (Flammula) carbonarius, *Fr.*
,, (Galera) hypnorum, *Batsch.*
,, (Stropharia) æruginosus, *Curt.*
,, (Hypholoma) fascicularis, *Huds.*
,, ,, lanaripes, *Cooke.**
,, (Psathyra) pennatus, *Fr.**
Coprinus radiatus, *Bolt.*
,, aratus, *B. and Br.**†
Cortinarius acutus, *Pers.**
,, pholideus, *Fr.**
,, violaceus, *Linn.**
Paxillus involutus, *Fr.*
,, Alexandri, *Fries.**†
Hygrophorus eburneus, *Fr.*
Lactarius subdulcis, *Fr.*
,, subumbonatus, *Lind.**
Russula fellea, *Fr.*

Marasmius insititius, *Fries.**
,, peronatus, *Fr.*
Boletus elegans, *Bull.**
,, luridus, *Schæf.**
Polyporus fomentarius, *Fr.**
,, squamosus, *Fr.**
Corticium Sambuci, *Pers.*

GASTROMYCETES.

Lycoperdon pyriforme, *Schæf.*
Scleroderma bovista, *Fr.**
Phallus impudicus, *Fr.*

ASCOMYCETES.

Xylaria polymorpha, *Grev.**
,, hypoxylon, *Fr.*
,, carpophila, *Fr.**
Valsa quaternata, *Fr.**
,, corylina, *Fries.**
,, coronata, *Fr.**
Sphæria inquilina, *Fr.**
,, phœstroma, *Mont.**
,, acuta, *Hoffm.*

The *Paxillus Alexandri*, Mr. Massee states, is the second British specimen, the first having been found in Hatfield Park, Essex, in 1888.

The following Lichens were seen and named by Mr. Massee :— *Calicium trachelinum*, Ach. (a rare species), *Cladonia pyxidata*, Fr., *Evernia furfuracea*, Mann., and *E. prunastri*, L., *Lecanora sophodes*, Ach., and *Xylographa flexella*, Ach.

A few mosses were collected by Mr. Hopkinson and submitted to Mr. A. E. Gibbs for determination, the following list being the result :—

ACROCARPI.

Mnium hornum, *L.*
Atrichum undulatum, *L.*
Polytrichum formosum, *Hedw.*

AMPHOCARPI.

Fissidens bryoides, *Hedw.*

PLEUROCARPI.

Brachythecium rutabulum, *L.*
Eurhynchium piliferum, *Schreb.*
,, prælongum, *Dill.*
Rhynchostegium confertum, *Dicks.*
Amblystegium serpens, *L.*
Hypnum cupressiforme, *L.*

Also the scale-moss, *Cepholozia bicuspidata*, Dum.

For weather the day was perfect, and the rich autumnal tints of the foliage, glistening in the bright sunshine, made the well-timbered park look its very best.

ORDINARY MEETING, 18TH NOVEMBER, 1890, AT WATFORD.

F. M. CAMPBELL, Esq., F.L.S., F.Z.S., etc., Vice-President, in the Chair.

Mr. Stephen Salter and Mr. H. Morten Turner were elected Members of the Society.

Mr. Frederick Downer, High Street, Watford, was proposed for membership.

The following papers were read :—

1. "Climatological Observations taken in Hertfordshire during the year 1889." By John Hopkinson, F.L.S., F.G.S., F.R.Met. Soc. (*Transactions*, Vol. VI, p. 77.)

2. "Half-a-Century's Rainfall in Hertfordshire." By John Hopkinson. (*Transactions*, Vol. VI, p. 81.)

Mr. HOPKINSON then referred to the lowering of the water-level, especially in regard to the supply of water to London. In the Lea district, he said, he had shown that the rainfall was not so

great as in the Colne district, yet much more water was taken from that district for the supply of London than was taken by the Colne Valley Water Company and from other deep wells in the neighbourhood of Watford; therefore they might expect that the water in the Lea district would be lowered more than the water here. There the New River Company was evidently taking more than could be spared, which was gradually lowering the water-level in the Chalk. Fifty years ago no one ever heard of deep wells running dry; now, with a considerably greater rainfall, the water level was getting low, and there seemed a probability, if the draw upon our underground resources continued to increase, that we should be short of water ourselves.

The Chairman said that this was becoming a serious matter, especially now that there was a chance of water being supplied to the great metropolis through the London County Council. Should it ever come about that a public body should have the control of the London water-supply, there would be an opportunity for local districts to express their opinion and object to more water being taken from them than at present. His own well at Hoddesdon was now pumped dry every day, and his neighbours' wells were pretty nearly in the same position, in fact every well which was not exceptionally deep. They were unfortunately placed, inasmuch as, while they had Mr. Hopkinson giving them valuable data as to the rainfall, they had no actual data as to the water-level. Along the valley from Broxbourne right up to the first spring between Ware and Hertford, the New River Company were sinking their deep wells. They were perfectly justified in what they were doing, but that was not the point, the water was being taken away and could not well be spared.

Mr. D. Hill said that he was afraid that the same process was beginning at Watford. They did not now have such floods as formerly, and undoubtedly the river was lowering in power. A steam-engine was now employed at the Watford flour-mill. He was perfectly certain that with the breweries, the Watford Local Board, the Colne Valley Water Company, and others drawing from the same source, they would at no distant day find that the same thing was happening here as in other parts of the county.

Mr. Hopkinson, in reply, said that had it not been for Mr. Hill's remark, they perhaps might have lost sight for a time of one thing which the water-works were doing, they were lowering the rivers. It was well known that the level of the water in our Chalk rivers, when flowing immediately on the Chalk without the intervention of any impervious bed, was the level of the underground water in the Chalk, therefore if the underground level be reduced, the level of the river will be reduced, and our Chalk rivers in course of time will cease to flow in dry seasons. Some years ago it was found that the volume of water in the Ver was decreasing. For the sake of the mills, several borings were made in the neighbourhood of Redbourn, and from them a large amount of water was obtained.

But the water which flowed from these borings would have gone into the river in springs; therefore all that trouble and expense might have been spared. No doubt the water in the Colne was much less than it was a good while ago, and would get less and less as the underground drain upon it increased.

3. "Notes on Birds observed in Hertfordshire during the year 1889." By George Rooper, F.Z.S. (*Transactions*, Vol. VI, p. 89.)

The Chairman asked whether the woodpecker mentioned was the larger or lesser spotted woodpecker; the larger appeared on the east side of Hertfordshire, and the lesser was more common in Surrey and Sussex. With regard to the eggs of the cuckoo, it seemed strange that a bird should not know its own eggs. He had seen a collection of forty cuckoo's eggs, made for the purpose of showing that they did not correspond with the eggs of the birds in whose nests the cuckoo laid them. Birds seemed to have very little appreciation of colour. The same remark applied to spiders. As to the woodcock being in this neighbourhood, every year they heard of woodcocks being with them, and, so far as he could trace, they began to breed in the neighbourhood of Hoddesdon about 35 years ago. It was now common to hear of a woodcock's nest. He also asked Mr. Rooper if he had ever seen White's thrush.

Mr. Stradling, referring to the carelessness some birds show with regard to eggs, mentioned that he once put four crocodile's eggs under a sitting hen. The hen sat until they were hatched out, and until then he did not know that a hen's countenance was capable of so much expression. She looked at the young crocodiles for two hours with the utmost astonishment, and then turned round and killed them all.

Mr. Lewis said that the bird he observed was the lesser spotted woodpecker, but that brought to him by Mr. John Dickenson, of Banwell's Wood Farm, was the larger, as also was that brought to him by the son of Mr. John Boyes, of Beaumont's Hall Farm, St. Albans.

Dr. Brett said that he knew a man who used to catch forty or fifty kingfishers in the season at Cassio Bridge. He asked whether it were correct that rooks struck the ground with their beaks to bring out worms. He also mentioned albinism in the sparrow in the neighbourhood of Watford, and expressed the hope that the members would help Mr. Rooper by making observations on our birds and sending the results to him.

Mr. Rooper said that he had never seen White's thrush. Birds were very frequently shot, destroyed, or caught, but unless they fell into the hands of a naturalist, no one knew anything about them. With regard to the rooks, though worms might be brought out by their searching for the cockchafer grubs, he did not believe that they did it by reason, or, as the boys said, went to do it. He thought that the larger spotted woodpecker was rarer than the lesser one. Though a large number of kingfishers might have been observed, he did not think, from the habits of the birds, that they

assembled in flocks. At High Elms they built three-quarters of a mile from the river, the old ones feeding the young until they were able to get to the water.

Ordinary Meeting, 15th December, 1890, at Watford.

George Rooper, Esq., F.Z.S., Vice-President, in the Chair.

Mr. Frederick Downer was elected a Member of the Society.

The following lecture was delivered:—

"Our Food-Fishes, their Friends and Foes." By Frank E. Beddard, M.A., F.Z.S., Prosector and Davis Lecturer to the Zoological Society of London.

The lecture, an abstract of which follows, was illustrated by means of the oxy-hydrogen lantern, kindly lent by Mr. S. Monckton White.

Mr. Beddard said that when he was honoured with the invitation to address this Society, he reflected a considerable time as to the subject which he should select, and after some consideration it occurred to him that he should like to bring before the members one of the utilitarian objects of the science he professed, that of zoology. It was a reproach to zoologists that they had not done so much for the well-being of mankind as the students of some other branches of science—chemistry, for instance—had done, but he would ask their attention to the investigations which were going on in France, Germany, and elsewhere, relating to one very important branch, in which the study of living organisms (Bacteria) exercised an important influence over the well-being of mankind.

The matter which he should say something about concerned the bearings of the science of zoology upon questions relating to food-fishes. There was a department of the Government, the official Board, which had a good deal to do with our fishes, but the work of that board was mainly devoted to the collection of statistics and their tabulation. The actual investigations upon food-fishes were carried on by various institutions throughout the country, of which the recently-formed Marine Biological Association was the most prominent. The work of that Association was two-fold. Its design on the one hand was to study the life-history of our various food-fishes, and to endeavour to ascertain from those studies the best methods of encouraging their propagation and fixing the close times when they should not be interfered with. At the same time another object was held in view, that of advancing zoology generally, particularly in its utilitarian aspects.

Since the laboratory of the Association at Plymouth had been open, the investigations had had a distinctly-important bearing on food-fishes. As they probably knew, the fishes, in a strict zoological sense, not crustaceans or mollusks, were propagated by means of eggs, of which each parent produced an enormous quantity. The eggs produced by a single cod-fish or salmon were numbered by millions. Since that was so, it was evident that an enormous

quantity of such eggs died, or from some cause did not undergo development. This was partly owing to their being subject to that very real fact, the struggle for existence, which goes on amongst ourselves as it does amongst the lower animals. The eggs of fishes had been proved to be deposited in one of two situations, either laid on rocks or sand at the bottom of the sea, or shed in the water, when they rise, owing to their lightness, to the top. But when they examined a quantity of the surface-water of the sea, they would find that, although they came across a good many eggs of fish, there were also countless hordes of other organisms, which struggled for survival, sometimes indirectly, in taking up room, sometimes directly, in devouring the eggs, and he would show, by means of the slides, the eggs and pelagic organisms to be found on the shores of this country. The first of these shown was the embryo of the common sole, the next, the young sole in a further stage of development. At this stage both eyes were on one side, and the fish was coloured on one side and pure white on the other. The coloured side was generally called the back of the sole, though that was not the fact. The eyes, moreover, shifted their position during growth, until the curious distortion occurred. The younger stage of the pilchard was next shown, with its globule of oil, which enables it to float upon the surface; and then the corresponding stage of the mackerel with its very large oil-globule, the size of this agreeing with the oily nature of the fish. Then came the angler-fish, which hides in the sand, throwing out its tentacles to excite the curiosity of other fish, which become its prey. This was one of the greatest enemies our food-fishes had to contend with, and although it was eaten, it was said not to be very good food.

Various stages in the development of our food-fishes were then illustrated and spoken of; and then the creatures which form a very large portion of the food of whales. Amongst these, crustaceans were shown, which served as food for many fishes. The spines which many of these bear might be supposed to be for their protection, but when shoals of herrings or mackerel came along, they did not stop to enquire, and did not even object to cannibalism. The spines, while they did not secure immunity to the possessor, often caused the death of its devourer, because they produce inflammation of the alimentary canal. The young of all these creatures were absolutely transparent, so that the sea seemed to be devoid of life; but if they got some sea-water in a pan and strained it, they would get a gelatinous mass, which consisted of the bodies of these creatures. The extreme transparency was said to be produced in order that they might be invisible to their foes, most of them being related to creatures at the bottom of the sea which are brightly coloured. But when they considered that their foes were mostly whales and other pelagic fish, it was difficult to believe that this transparency was an advantage to them at all. The whale fills its mouth with gallon after gallon of water, which it strains, swallowing the solid residuum. Therefore of that fact they had no adequate explanation.

Creatures whose first state is that of the tadpole, the axolotl being instanced, were referred to, and the lecturer then came to the immature young of the oyster. He explained that oysters had a free-swimming stage when young, so that they could extend their range. In bad weather they could not settle down, and so they died. The weather of course could not be regulated, but suitable ground for them to settle upon might be furnished. The surface must be clean, without weeds or other organisms growing upon it. The "native" oyster was an indigenous form found between Orfordness and Whitstable. What it is that conduces to its smallness of size and peculiar flavour he did not know. Other creatures, including the Medusæ, were shown and spoken of. In one single mile of the sea there were no less than 800 tons of the organisms he had instanced, though individually they weigh next to nothing.

The point of these figures was to emphasize the enormous struggle for existence in the surface-waters between the fish and other organisms. They were interested in the development of the food-fishes and did not care for the other organisms, but they must enquire how far steps could be taken to protect the fish from those organisms. In the first place, the fish were preyed upon, but it was quite possible to form parks, enclosed areas of shallow water, which might be stocked with eggs collected from the surface of the sea, and when they were developed they might be liberated into the open water. It was a familiar experience with those who had had to do with sea-fishing, that many areas became depopulated. At Plymouth, near the Eddystone Lighthouse, the sea had been nearly fished out. By providing suitable parks, and collecting ova, such barren spots could be perfectly well stocked, but this seemed to be difficult, because, before they could collect the young fish, these might be devoured by their numerous enemies. What could be done, was to take the fish, squeeze out the eggs, and hatch them artificially. With the sole this had been tried successfully by the Association at Plymouth. When that was accomplished they could be moved into the open sea and the barren spots stocked with them. But this could not be carried on without considerable appliances. The biological station at Plymouth was very well set up with many things. There were excellent apartments and tables for the use of zoologists, and there was an excellent supply of water, but it was not well furnished with steam-boats. It had only one steam-boat, and that of such an inferior nature that every time the naturalists go to sea they do so at the peril of their lives. What the Association wanted was a boat which would cost £3000 or so, and although the Government had been fairly generous, giving an annual grant, it was still greatly in need of funds. If they could be largely increased, there was no doubt whatever that very improved methods in the way of the cultivation and propagation of food-fishes might be successfully introduced, the price of fish reduced, the consumption of it more widely spread, the distress in the East End of London and other

places lessened, and fish become the food of the many instead of being only the food of the rich.

The Chairman asked why they found roe in soles but never milt.

Mr. Stradling enquired as to the possibility of stocking ditches and other fresh waters with such sea-fish as the sole, as they knew that some fish lived in the sea and fresh water indiscriminately.

Dr. Brett referred to the experiments made by the late Mr. Frank Buckland, Mr. Jonathan King, and Dr. Hood, in stocking the river at Watford with fish. It was said that a cross had occurred between the Colne trout and the Neufchâtel trout put into the Colne at Otterspool, as trout having the characteristics of both were now caught. Fish were not now being cultivated here so much, but Lord Essex and the Hon. A. Holland-Hibbert had introduced grayling, which were increasing. It was useless to overstock water with fish, for they would lack their proper food.

The Lecturer said that probably the reason why soles with roe were more common than those with milt was that the male fish were rarer and more wary than the female, so that few found their way to the market. It was not generally known that many marine fish will live in fresh water. The salmon must go to fresh water at certain seasons of the year, and many other fish attempted to do the same thing. The herring sometimes spawned in positively fresh water. At Plymouth, where the sound itself is brackish, it was believed to be perfectly possible to stock it with marine fish.

Ordinary Meeting, 18th December, 1890, at St. Albans.

F. M. Campbell, Esq., F.L.S., F.Z.S., etc., Vice-President, in the Chair.

The following papers were read:—

1. "On Rainfall and Water-supply." By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc. (*Transactions*, Vol. VI, p. 129.*)

Mr. Hopkinson concluded his paper with the proposition that the following resolution be passed by the Society:—"That the Hertfordshire County Council be requested to take the necessary steps for opposing any clauses in the Bills of the London Vestries and the Corporation of London now before Parliament relating to the Water-supply of the Metropolis, which, by giving to either of these bodies power to abstract a large quantity of water from the underground reservoir in the catchment basins of either the Colne or the Lea, thus unduly lowering the plane of saturation of the Chalk, are likely to have a prejudicial effect upon the welfare of the County and its inhabitants."

The Chairman said that the subject of the paper was a most important one. Mr. Hopkinson had pointed out that the reserve of water under London, and indeed throughout the whole of the Home Counties, was being reduced. Already in his own

* Incorporated in the paper on "Water and Water-supply."

district, the neighbourhood of Hoddesdon, he saw signs of the water diminishing, for the level of the water in wells was sinking markedly. All along the New River, shafts were being sunk, and drawing water which could ill be spared. There was only one way in which they could hope to protect their water-supply, and that was by applying to the County Council to oppose the Bills before Parliament.

Letters were read from Dr. Brett, the Honourable A. H. Holland-Hibbert, Mr. F. W. Silvester, and Mr. H. J. Toulmin, recognising the importance of the subject, and Dr. Morison and Mr. Urban Smith urged the desirability of petitioning the County Council in the matter.

The resolution suggested by Mr. Hopkinson was then formally proposed by him, seconded by Dr. Morison, and carried unanimously.

Maps and diagrams were exhibited in illustration of the paper.

2. "On a Meteorite observed in Switzerland." By H. George Fordham, F.G.S. (*Transactions*, Vol. VI, p. 193.)

A letter was read from Dr. Brett stating that a brilliant meteor had been seen by his dispenser and his gardener at about half-past nine on Sunday night, the 14th inst., and Mrs. Arnold said that she had seen it at Redbourn Bury, and that it gave a bluish light.

3. "Notes on Tineina and other Lepidoptera observed in the neighbourhood of Sandridge, Herts." By A. F. Griffith, M.A. (*Transactions*, Vol. VI, p. 97.)

Ordinary Meeting, 26th January, 1891, at Watford.

John Hopkinson, Esq., F.L.S., F.G.S., etc., Vice-President, in the Chair.

Mr. G. Upton Robins, F.S.A., Delaport, Wheathampstead, was proposed for membership of the Society.

A lecture was delivered, of which the following is an abstract:—

"Amongst Wild Beasts." By Arthur Stradling, C.M.Z.S.

Mr. Stradling said that it had been his privilege to see something of wild beasts in the course of his wanderings over "this little planet of ours," but in his lecture he should take his audience no further than the Zoological Gardens, Regent's Park.

Zoology was one of the oldest scientific studies. The Zoological Society of London dated its existence from 1826. The question might be asked: "Why did certain members secede from the Linnean Society and form this new Society, when the former already included everything biological in its work?" This brought him to the fact that the main idea of the new Society was to acclimatize and domesticate mammals, birds, and reptiles which up to that time had never been successfully reared in England. This idea was soon found impracticable, and it was the greatest wonder that the Society did not there and then collapse. Acclimatization was never carried to a successful issue, and perhaps it was

as well that it was so, for subsequent events had shown that it was not unattended by danger, as witness the introduction of the sparrow into the United States. At the outset the Society attached great importance to its farm for acclimatizing at Kingston, but it was closed in a short time on account of its obvious inutility. The Gardens were opened in 1828, and despite the facts that the admission was 2*s.* 6*d.*, that London had a much smaller population than at the present time, and that there were hardly any facilities for travelling, there was a phenomenally large attendance during the first year. The Society began in a small way, having only five acres of ground for the gardens. These were leased from the Commissioners of Woods and Forests, who imposed certain unnecessary restrictions. Amongst them was one that no building of more than eight feet in height should be erected. Of course they could well understand that a building of eight feet would be useful for some of the animals in the Zoo, but not for such creatures as giraffes and elephants. After a present of some beautiful birds for the ornamental waters in the parks of London, the Commissioners withdrew many of the restrictions. At this time a high fence had to be erected all round the Zoo to keep out the hares which, strange as it might now seem, at that time literally over-ran Regent's Park. There were no hares now, but there were animals which did quite as much damage—innumerable cats, which committed great havoc among the young birds.

The menagerie, farm, and museum were at first the only things maintained by the Society, but subsequently there was an offshoot in the fortnightly meeting of members of the Society, which had since done much useful work in the science of zoology. The museum was given up in 1856 because it was felt that the zoological department of the British Museum fulfilled all the requirements of one city. The magnificent library contained works valued at thousands of pounds, and the animals in the Gardens were now worth £29,000. The specimens were obtained either by purchase or exchange, or received as gifts, whilst some were housed during the winter for private individuals, free of cost. Of course, keeping these animals entailed an enormous expense; and another serious item in the year's expenditure was the purchasing of animals. About 1000 animals died yearly, and of necessity these had to be replaced. Many were given; he himself had during his wanderings sent about 300, but it was necessary to purchase many animals yearly.

He wished he could say that the Gardens were without fault. They were on the London Clay, a fact which was responsible for the high rate of mortality amongst the animals.

Having referred to some of the continental gardens, the lecturer urged the necessity of some collection being kept of our indigenous animals. By far the greater majority of Englishmen were more familiar with lions and tigers than with the more rare species of English animals. Who amongst them had seen a wild badger, pole-cat, or otter alive? All these animals were rapidly disappearing. The wild cat was now almost extinct; and the

dormouse and field-mouse were fast following in their track. Many insects were rarer than they used to be, and our fish were gradually being driven to greater depths by the increase of steam-navigation. It seemed to him that they should establish Gardens where all these things could be exhibited, and he believed they could be made attractive and remunerative. There was no limitation to the interesting experiments and observations which might be made. He thought it possible that some day they might be able to have an institution of this kind in Watford.

[In the course of the lecture Mr. Stradling gave a large amount of information as to the cost of the animals which were purchased, the expense of keeping them, and the nature and quantity of their food.]

Ordinary Meeting, 27th January, 1891, at Hertford.

Richard B. Croft, Esq., R.N., F.L.S., etc., Vice-President, in the Chair.

Mr. Robert P. Barclay, High Leigh, Hoddesdon; Mr. B. H. R. Daltry, Queen's Road, Hertford; and Mr. F. A. Hawks, Springfield, Hertford, were proposed for membership of the Society.

The following paper was read:—

"On the Abstraction of Water from the Chalk of Hertfordshire." By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc. (*Transactions*, Vol. VI, p. 129.*)

Mr. F. M. Campbell said that there were a few points which the County Council and the public ought to bear in mind. Within four and a quarter miles of the course of the New River there were five deep wells from which there were headings. These headings were six feet high and four and a half feet wide, and penetrated into the chalk with the object of taking the water from the chalk to those deep wells. But these cuttings or tunnels came across springs, and the water from these was discharged into the wells instead of rising to the surface, and the result was great damage to watercress beds. It was not, however, a question of damage to these only, but it was a question of the water-supply throughout the whole Lea valley so far as agriculture was concerned. Those who had seen how the water put on the surface at the sewage-farm sank when the neighbouring pumps were working, would form some opinion as to the very trying condition those wells had produced in the soil, so far as trees, herbs, and crops all over the district were concerned. What was feared was that sooner or later the fields in the agricultural districts might be reduced to the condition of a dry, hard, common, turnpike road. That was no exaggeration. The only way by which to stop it, was to find some means of preventing the abstraction of water from the great basin which supplied the water to the River Lea. That was a matter

* Incorporated in the paper on "Water and Water-supply."

of difficulty. No doubt certain water companies had Parliamentary powers to remove water from the neighbourhood; but those powers ought to be examined, and there ought to be some limit to them. The question also arose whether the water companies had not exceeded the powers which the legislature intended them to have. He had noticed in his own neighbourhood that pumping from these wells had begun to dry the surface-wells, and if any one thought that could happen without being accompanied by weakness of the surrounding vegetation, he would be greatly mistaken. It was, therefore, really a question for agriculturists as well as for those in the towns. It was an economic as well as a sanitary question. So far as the County Council was concerned, he hoped the matter would be taken up very seriously. He should like to see the whole question treated by a special committee, and no doubt, in course of time, they would be obliged to enter into the matter far more seriously than they did last Monday. The appointment of a committee to examine the powers of the London water companies would have the effect of limiting or checking, if not removing altogether, anything that might be prejudicial to the interests of the county. But they wanted to go further. They wanted to know how far the injurious powers which were at present exercised could be stopped, and if they had even to pay compensation it would be better to face the difficulty at once, and pay that compensation, than to look forward to the future and find themselves without a supply of water, which was essential to their health and happiness and industries. He hoped they would not be satisfied with a mere empty inquiry. They were often told that the pollution of rivers ought to be prevented; but he would submit that the Lea and most other rivers were navigable, and they could not get perfectly pure water from a navigable river. The London water companies were coming down upon the towns in the neighbourhood of, and above, Hertford, and telling them not to turn their sewage into the Lea; but why should those towns be put to such an enormous expense in order to provide fresh water for people in London who could well afford to get it elsewhere? He begged to move "That the Hertfordshire Natural History Society earnestly desires the Herts County Council to investigate the whole question of the abstraction and removal of water from the Chalk basin of Hertfordshire by the London water companies."

Mr. A. P. McMullen, in seconding the motion, said he regretted that the County Council did not decide that the subject should be considered by a large Committee, or even by the whole Council, but if the whole question of the water-supply should be considered by the Finance and General Purposes Committee, he hoped Mr. Campbell would be on that Committee, and that there would be a good many practical and scientific men on it. They were face to face with a great danger, and they should take decided action. He thought the Metropolis was rich enough to get a water-supply from elsewhere, and so leave the people in this agricultural district to have that which was really intended by nature for them, and

that the County Council should take strong and decided action in the matter.

The resolution was unanimously agreed to.

The Chairman remarked that that was not the first time the question had been before the Society, for in March, 1882, a paper, by Mr. Greg and himself, on the rivers Rib and Quin, was read; and in that paper it was stated that the Rib was often dry, and that the water coming down the two rivers in the summer time was less than it was in the last century. He could not help thinking that the great amount of land drained now must make some difference to the quantity of water in the streams. He should like to hear the opinions of some of the watercress growers.

Mr. J. Welch, watercress grower, Old Highway, Hoddesdon, said he had felt very ill effects from the pumping, as he lost the greater part of the water for watercress growing. There must be a lot of waste by the New River Company, for, to prevent the water from freezing, and the banks from being damaged by ice, the river in the winter was kept as full as possible. He thought the abstraction of water was chiefly due to the construction of headings. His watercress beds were a mile from the pumping station, and immediately the pumping began the effects were apparent.

Mr. C. E. Longmore quite agreed with the opinion that London should go further afield for a supply of water, because navigable rivers, such as the Lea and the Thames, could not safely be made sources of supply. He was glad that the County Council had taken steps to endeavour to prevent the further abstraction of water; but there was a more important point, and that was to see that these new or old companies, whichever it might be, when they came into power, would not have increased powers, and power to tell the different authorities in the district to keep their water-supply for those companies pure. In this district they had had immense difficulty in dealing with the water companies. If any poor little place started a scheme for its own sewage and proposed to put its effluent water into the Lea, they met with every obstruction and were put to great expense before they could carry out the work. Great as was the difficulty of dealing with the water companies, it would be still more difficult to deal with the popularly elected bodies in London, as they would have more influence in Parliament. If the water companies were to get a supply, it should be laid down, at the start, that that water must be kept pure at the expense of the ratepayers of London, and not at the expense of the ratepayers of the district from which it was derived.

Mr. Durrant said that he should like to know whether the level of the water in the wells in the Lea basin was lower than it was ten years ago, and what means could be taken to prevent undue waste of water.

Mr. Campbell stated that the water-level in the Lea valley was considerably lower, and that the water in the Ware well was 18 feet lower than it was 18 or 20 years ago.

Mr. Boyd, of Ware, said that the water had been gradually getting lower, and was very much lower this year than usual.

Mr. A. Baker asked if the spring, St. Am's well, was as great as it used to be.

Dr. Turner said that it was sometimes dry.

Dr. Shelly said he should like to add his opinion to that of the Chairman, as to the effect of the increased drainage and high farming. The water was thus carried off more quickly. The same might be said in regard to rivers which had been deepened, and the scour made very much greater than it was some years ago.

Mr. Hopkinson said that the rate of depression in the Colne valley was almost the same as at Ware, about a foot per annum, and the question was, what would probably be the result of these continued abstractions with a long series of dry years? The effect would be very much more serious than it was at present, because agriculture, as well as other industries, would be affected. They all knew what a great waste there was in manuring on the Chalk. The lower the depression in the water-level—the lower the water was from the surface—and the more rapidly would the manure put on the land sink through. That was a very serious question. He had heard that at several places, where mills used to be worked by water, engines were now being laid down because the water was insufficient, and that had been more marked since the East London Water Company and the New River Company had begun to take more water from the district. The reduction in the water-level had been going on for a number of years, and even if the pumping were stopped, it would be a great number of years before the level could be brought up again. As to the waste of water, he said that with a constant supply and first-class fittings there would be less waste than with an intermittent supply.

Maps, diagrams, and tables were exhibited in illustration of the paper.

Anniversary Meeting, 16th February, 1891.

(At Watford.)

The Right Honourable the Earl of Clarendon, President, in the Chair.

The Report of the Council for 1890, and the Treasurer's Account of Income and Expenditure, were read and adopted.

The President delivered an Address on "The Horse." (*Transactions*, Vol. VI, p. 103.)

The following gentlemen were duly elected as the Officers and Council for the ensuing year:—

President.—John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.

Vice-Presidents.—Alfred T. Brett, M.D.; F. M. Campbell, F.L.S., F.Z.S., F.R.M.S., F.E.S.; the Right Honourable the Earl of Clarendon; Richard B. Croft, R.N., F.L.S., F.R.M.S.; William Ransom, F.S.A., F.L.S.; George Rooper, F.Z.S.

Treasurer.—John Weall.

Hon. Secretary.—John Morison, M.D., D.P.H., F.G.S.

Librarian.—Upfield Green, F.G.S.

Curator.—A. E. Gibbs, F.L.S.

Other Members.—Prof. Attfield, M.A., Ph.D., F.R.S., F.I.C., F.C.S.; F. Haycraft Berry, M.D.; Percival Bosanquet; Arthur M. Brown, M.A.; W. R. Carter; Alfred Eteson, M.D.; John Evans, D.C.L., LL.D., Treas. R.S., Pres. S.A., F.L.S., F.G.S.; Augustus Hawks; C. E. Shelly, M.A., M.D.; F. W. Silvester, F.R.Met.Soc.; Arthur Stradling, C.M.Z.S.; John Thornhill, F.L.S.

The thanks of the Society were accorded to the Right Honourable the Earl of Clarendon retiring from the office of President; to Mr. Augustus Hawks and Mr. Arthur Stradling retiring from the office of Vice-President; to Dr. C. E. Shelly retiring from the office of Secretary for East Herts; and to Mr. Isaac Robinson and the Rev. E. T. Vaughan retiring from the Council.

Report of the Council for 1890.

In presenting the 16th Annual Report, the Council of the Hertfordshire Natural History Society and Field Club has much pleasure in stating that the Society still maintains a vigorous and flourishing condition. The number of meetings held during 1890 was almost up to the average of former years. It is to be regretted, however, that the attendance of members at those meetings was not quite so good as might be desired. The Council ventures to hope that the present year will see a very considerable improvement in this respect, especially as the last two meetings have been very numerously attended.

During the year one honorary member and sixteen ordinary members have been elected, thirty members have resigned, and we have to mourn the loss of five members by death. Amongst the latter is Mr. J. W. Robins, of Watford, a member of the Council, and Mrs. John Evans, of Nash Mills, one of our oldest members, who, with her husband, Dr. John Evans, F.R.S., by entertaining the members and their friends at our Field Meetings, and in other ways, has done so much to promote the interests of the Society since its formation in 1875.

The census of the Society at the end of the years 1889 and 1890 was as follows:—

	1889.	1890.
Honorary Members	19	20
Life Members	42	47
Annual Subscribers	193	169
	254	236

The following papers or lectures have been read or delivered during the year:—

Jan. 21, at Watford.—Seeds and Fruits; their Structure and Migrations; by A. E. Gibbs, F.L.S.
Feb. 21, at Watford.—Anniversary Address: Field Sports and their bearing on the National Character; by the President, the Right Honourable the Earl of Clarendon.
March 16, at Watford.—Meteorological Observations taken at The Grange, St. Albans, during the year 1889; by John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.
—— A Record of Water-level in a deep Chalk Well at Odsey Grange, Royston, 1878–88; by H. George Fordham, F.G.S.
—— The Swan; by S. Monckton White.
April 16, at St. Albans.—On Local Scientific Investigation in connection with Committees of the British Association; by John Hopkinson, F.L.S., F.G.S., etc.
—— On Geological Photography in Hertfordshire; by John Hopkinson.
—— The Art of Photography; by S. Monckton White.
—— 22, at Watford.—Report on the Rainfall in Hertfordshire in 1889; by John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.
—— Temperature and Rainfall at Hitchin, 1850–89; by John Hopkinson.
—— Some Hertfordshire Well-sections.—Second Paper; by W. Whitaker, B.A., F.R.S., F.G.S., Assoc. Inst. C.E.
—— Hertfordshire Plant-records, 1886–89; by John Hopkinson.
Nov. 18, at Watford.—Climatological Observations taken in Hertfordshire during the year 1889; by John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.
—— Half-a-Century's Rainfall in Hertfordshire; by John Hopkinson.
—— Notes on Birds observed in Hertfordshire during the year 1889; by George Rooper, F.Z.S.
Dec. 15, at Watford.—Our Food-Fishes: their Friends and Foes; by Frank E. Beddard, M.A., F.Z.S.
—— 18, at St. Albans.—On Rainfall and Water-Supply; by John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.
—— On a Meteorite observed in Switzerland; by H. George Fordham, F.G.S.
—— Notes on Tineina and other Lepidoptera observed in the Neighbourhood of Sandridge, Herts; by A. F. Griffith, M.A.

The following Field Meetings were held during the year:—

April 19.—North Mimms, Hatfield.
May 10.—Redbourn and Harpenden.
—— 31.—Rothamsted, Harpenden.
June 14.—The Barton Hills.
July 19.—Shenley and Radlett.
—— 30.—Park Street, St. Albans.
Oct. 8.—Hatfield Park (annual fungus foray).

The thanks of the Society are due, for hospitality kindly afforded at the Field Meetings, to Dr. A. Maclean, Harpenden Hall; to Sir John B. Lawes, Bart., Rothamsted; and to Mr. F. W. Silvester, Hedges, St. Albans.

The fifth volume of the present series of the Society's 'Transactions' has been completed and the sixth volume has been commenced, two parts of the former and three of the latter, containing 176 pages and three plates, having been published during the year. A supplementary catalogue of the Library, containing the additions, exclusive of pamphlets, for the last four and a half years, has also been issued to the Members. The fifth volume of the 'Transactions' is almost entirely devoted to papers of local interest, the only exceptions being the Anniversary Addresses delivered in 1888 and 1889, on the 'Means of Protection possessed by Plants,' and on the

'Eyes of Animals.' In meteorology and phenology there are the usual annual reports; a paper of thirty pages on the meteorite which passed over our county in November, 1887; a record of water-level in North Herts; and a naturalist's calendar for South-west Herts. There is only one purely geological paper, that on the Chalk Rock, but the record of water-level, and a paper on 'Pre-historic Man in Britain,' contain much of geological interest. In zoology there are the usual annual reports on the insects and birds observed; three papers on Hertfordshire Lepidoptera; and a description of a new spider from Hoddesdon. One zoological paper, that on the Hessian-fly, derives its local interest from the fact that our county has the unenviable notoriety of being the first in which this pest was observed in Britain; another, on the 'Nests and Habits of Birds,' is only partially founded on observations in Hertfordshire; and the anthropological paper, on 'Pre-historic Man,' already referred to, while having a general bearing on the Quaternary geology of our county, has only incidental references to it. There are no botanical papers in this volume except a note suggesting that the diseases of, and injuries to, plants should be studied by our Members. The late Mr. A. R. Pryor's 'Flora of Hertfordshire,' published by the Society about three years ago, has doubtless taken the place of contributions on our local flora, but there is a wide field open for investigations on the life-histories of our native plants. The thanks of the Society are due to Mr. H. George Fordham for the chart showing variations in the water-level in the Chalk at Barley, and the map showing the area affected by the meteorite of November, 1887; and to Mr. Hopkinson for the map of Hertfordshire showing its Climatological Stations.

The library is in a satisfactory condition, and numerous books and periodicals have been received by the Society during the past year, either as gifts or in exchange. The Council desires to call attention to the fact that arrangements have been made for circulating the following journals amongst the Members:—'The Entomologist,' 'Journal of Botany,' 'Meteorological Magazine,' 'Midland Naturalist,' 'Naturalist,' and 'Zoologist,' monthly; "Grevillea,' and 'Journal of Conchology,' quarterly. The conditions of circulation will be furnished on application to the librarian.

The Council regrets that the Secretary for East Herts, Dr. C. E. Shelly, has found it necessary to resign his office, which he has held since 1886, and desires to place on record the appreciation of the members of the services which he has rendered to the Society for the last five years. It has not yet been found practicable to nominate a successor.

In conclusion, the Council desires to express the thanks of the Society to the Committee of the Watford Public Library for the accommodation afforded for their library and the Watford meetings.

INCOME AND EXPENDITURE FOR THE YEAR ENDING 31st DECEMBER, 1890.

Dr.	£	s.	d.
To Balance from 1889	53	2	3
,, Entrance Fees	8	10	0
,, Subscriptions for 1888	3	10	0
,, ,, ,, 1889	11	0	0
,, ,, ,, 1890	60	0	0
,, ,, ,, 1891	37	0	0
,, ,, ,, 1892	1	10	0
,, Dividends on £100 India 3 per cent. Stock, Oct. 1888 to April 1890	5	5	0
,, Dividends on £130 India 3 per cent. Stock, July 1890 to Jan. 1891	2	18	6
,, Sale of Publications ['Flora of Hertfordshire' £3 19*s.*; 'Transactions' £1 15*s.* 4*d.*; less expenses]	5	14	4
	£188	10	1

Cr.	£	s.	d.
By Printing 'Transactions'	66	3	6
,, ,, Circulars	8	10	9
,, Expenses of Meetings [*]	4	9	6
,, Library	9	14	3
,, Salary of Assistant	6	0	0
,, Postages and various small expenses	15	8	6
,, Fire Insurance	0	7	7
,, Purchase of £30 India 3 per cent. Stock	30	3	0
,, Balance at Bank	47	13	0
	£188	10	1

Amount invested in the purchase of £130 India 3 per cent. Stock . . . . £126 15*s.* 6*d.*

Audited and found correct this 15th day of February, 1891, { E. M. CHATER, DANIEL HILL.

[* Due to Watford Public Library . . . £5.]

Additions to the Library in 1890.

Presented.

Title.	Donor.
British Association for the Advancement of Science. Report, 1889. 8vo. London, 1890.	*The Association.*
Cooke, M. C. (Ed.) Grevillea. Vol. xviii, Nos. 87–90. 8vo. London, 1890.	*The Editor.*
Evans, J. Anniversary Address to the Society of Antiquaries, 1890. 8vo. London, 1890.	*The Author.*
Green, A. H. Geology for Students. Part 1. Physical Geology. 8vo. London, 1877.	*Mr. J. Hopkinson.*
Linnean Society. Journal. Botany. Vol. xxvi, No. 174. Vol. xxvii, Nos. 181, 182. 8vo. London, 1890.	*Mr. R. B. Croft.*
Rooper, G. Autobiography of a Salmon. 8vo. London, 1886.	*The Author.*
——. Adventures of a Salmon. 8vo. London, 1886.	,,
Symons, J. G. (Ed.) Monthly Meteorological Magazine. Vol. xv. 8vo. London, 1890.	*The Editor.*
Whitaker, W. On the Probability of finding Coal in the South East of England. 8vo. Reigate, 1886.	*The Author.*

Received in Exchange.

American Museum of Natural History. Bulletin. Vol. iii, No. 1. 8vo. New York, 1890.

Belfast Natural History Society. Proceedings. Series 2, Vol. iii, No. 3. 8vo. Belfast, 1889.

Conchology, Journal of. Vol. vi, Nos. 5–8. 8vo. Leeds, 1890.

Glasgow Natural History Society. Proceedings and Transactions. Vol. ii, No. 2; Vol. iii, No. 1. 8vo. Glasgow, 1888–89.

————, Philosophical Society of. Proceedings. Vol. xxi. 8vo. Glasgow, 1890.

London, Geological Society of. Abstracts of the Proceedings, Session 1889–90. 8vo. London, 1890.

————. Geologists' Association. Proceedings. Vol. xi, Nos. 6–8. 8vo. London, 1890.

————. Quekett Microscopical Club. Journal. Series 2, Vol. iv, Nos. 26–28. 8vo. London, 1890.

————. Royal Meteorological Society. Journal. Vol. xv, No. 72; Vol. xvi, Nos. 73–76. 8vo. London, 1889–90.

————. ————. The Meteorological Record. Vol. ix, Nos. 34, 35. 8vo. London, 1889.

Manchester Geological Society. Transactions. Vol. xx, parts 14–19. 8vo. Manchester, 1889.

———— Microscopical Society. Transactions. 8vo. Manchester, 1889.

Marlborough College Natural History Society. Report for 1889. No. 38. 8vo. Marlborough, 1890.

Midland Naturalist. Vol. xiii. 8vo. Birmingham, 1890.

Naturalist. New Series. Vol. xv. 8vo. Leeds, 1890.

New York Academy of Sciences. Transactions. Vol. ix, Nos. 1, 2. 8vo. New York, 1889–90.

———— State Museum of Natural History. 43rd Annual Report, for 1889. 8vo. Albany, 1890.

United States Geological Survey. Seventh Annual Report, for 1885–86. 4to. Washington, 1888. Eighth Annual Report, for 1886–87. (2 Vols.) *ib.*, 1889.

————. Monographs. Vol. xiv. Fossil Fishes and Fossil Plants of the Triassic Rocks of New Jersey and the Connecticut Valley. By J. S. Newberry. *ib.* 1888.

————. Bulletin. Nos. 48–53. 8vo. Washington, 1889–90.

WILTSHIRE NATURAL HISTORY SOCIETY. Magazine. Vol. xxiv, No. 72. 8vo. Devizes, 1889.
YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY. Proceedings. New Series, vol. xi, part 2. 8vo. Halifax, 1890.

PURCHASED.

BOTANY, JOURNAL OF. New Series, vol. xxviii. 8vo. London, 1890.
CAMERON, P. A Monograph of the British Phytophagous Hymenoptera. Vol. iii. (*Ray Society.*) 8vo. London, 1890.
ENTOMOLOGIST. Vol. xxiii. 8vo. London, 1890.
YEAR BOOK of the Scientific and Learned Societies of Great Britain and Ireland. Seventh Annual Issue. 8vo. London, 1890.
ZOOLOGIST. 3rd Series. Vol. xiv. 8vo. London, 1890.

ORDINARY MEETING, 13TH MARCH, 1891, AT HITCHIN.

WILLIAM RANSOM, Esq., F.S.A., F.L.S., Vice-President, in the Chair.

Mr. Lewis Evans, Belswains, Hemel Hempstead; Dr. William Gruggen, L.R.C.P.E., 11, Montpellier Road, Ealing; Miss Bertha Innes, St. John's Road, Watford; Mr. Frederick Lowe, Fulham, Tring; Mr. Arthur Hampton Longman, M.A., Shendish, Hemel Hempstead; and Mr. Edward Slocombe, Oxhey Warren, Watford, were proposed for membership of the Society.

The following paper was read:—

"Water and its Circulation above and beneath the Surface of the Earth." By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc., President. (*Transactions*, Vol. VI, p. 129.*)

Maps, diagrams, and tables were exhibited in illustration of the paper.

The meeting was held in conjunction with the Hitchin Natural History Club, on behalf of which Mr. William Hill proposed and Mr. J. H. Tuke seconded a similar resolution to that passed by the Hertfordshire Natural History Society on the 27th of January (see p. xlix), and it was carried unanimously.

ORDINARY MEETING, 16TH MARCH, 1891, AT WATFORD.

JOHN HOPKINSON, Esq., F.L.S., F.G.S., etc., President, in the Chair.

Mr. Robert P. Barclay, Mr. B. H. R. Daltry, Mr. Lewis Evans, Dr. William Gruggen, Mr. F. A. Hawks, Miss Bertha Innes, Mr. A. H. Longman, M.A., Mr. Frederick Lowe, Mr. G. Upton Robins, F.S.A., and Mr. Edward Slocombe, were elected Members of the Society.

The following papers were read:—

1. "A Simple Method of taking Phenological Observations." By Edward Mawley, F.R.Met.Soc., F.R.H.S. (*Transactions*, Vol. VI, p. 117.)

* Incorporated in the paper on "Water and Water-supply."

2. "Notes on Birds observed in Hertfordshire during the year 1890, and the early part of 1891." By George Rooper, F.Z.S. (*Transactions*, Vol. VI, p. 123.)

Mr. Stradling asked Mr. Rooper if he could give any explanation of the unusual prevalence of albinism, not only during last winter, but throughout the year. Many more cases were recorded in France than ever before, notably that of the swallow. Mr. Rooper had alluded to the reprehensible practice of the bittern in swallowing snakes. From observations he had made he thought that almost every bird would swallow a snake of suitable size; every insectivorous bird seemed to look upon a snake as a delicacy very much to be desired. Last year he heard of a pheasant which when killed was found to have eaten 440 of the very destructive larvæ of the daddy-longlegs, a large quantity of wire-worms, and a young viper. Peacocks had a great predilection for vipers. A gentleman who purchased an island that was infested with snakes, turned down a number of pea-fowl which exterminated all the vipers on the island.

Mr. Rooper said that he could not give any explanation with regard to the albinism, which had no doubt been very prevalent.

The following papers were taken as read:—

1. "Meteorological Observations taken at The Grange, St. Albans, during the year 1890." By the President. (*Transactions*, Vol. VI, p. 169.)

2. "Report on Phenological Phenomena observed in Hertfordshire during the years 1889 and 1890. By the President. (*Transactions*, Vol. VI, p. 114.)

Ordinary Meeting, 23rd March, 1891, at St. Albans.

John Hopkinson, Esq., F.L.S., F.G.S., etc., President, in the Chair.

Mr. Richard Gibbs, The Hollies, St. Albans; Mr. Henry Lubbock, Newberries, Radlett; and Mr. T. Foster Woodman, St. Peter's Street, St. Albans, were proposed for membership of the Society.

The following lecture was delivered:—

"The Application of Photography to Meteorology." By Arthur W. Clayden, M.A., F.G.S., F.C.S., F.R.Met.Soc. (*Transactions*, Vol. VI, p. 162.)

The President said that they were fortunate in having with them the Chairman of the British Association Committee on Meteorological Photography, Mr. G. J. Symons, F.R.S., who was well known as the organiser of the most numerous body of observers in any department of science—observers of rainfall.

Mr. Symons said that Mr. Clayden had been talking about his slides as if everybody had been taking similar photographs, whereas four-fifths of them were new and illustrated phenomena which no

one else had photographed. Hitherto no one had thought of photographing snow-crystals on a large scale, or hoar-frost, so as to show their structure. He also referred to the deposit of lead from the smoke in the chimneys of smelting works, which resembles the incrustation of hoar-frost on wire netting, and the cause of which is unknown; and he said that the Society could help the British Association Committee on Geological Photography as well as that on Meteorological Photography, in both of which their President was interested.

The lecture was illustrated by means of the oxy-hydrogen lantern, kindly lent by Mr. S. Monckton White, to whom the thanks of the Society were accorded.

Ordinary Meeting, 13th April, 1891, at Watford.

John Hopkinson, Esq., F.L.S., F.G.S., etc., President, in the Chair.

Mr. Richard Gibbs, Mr. Henry Lubbock, and Mr. T. Foster Woodman, were elected Members of the Society.

Mr. Ernest Brunton, Frogmore House, St. Albans, and Dr. Henry Case, Medical Superintendent, Leavesden Asylum, Watford, were proposed for membership.

The following papers were read:—

1. "The Percolation of Rain through comparatively Light and through comparatively Heavy Soil." By Edward Mawley, F.R.Met.Soc., F.R.H.S. (*Transactions*, Vol. VI, p. 175.)

The President said that this was a most important question, and one of the observations he would make with regard to it was that the result of these experiments with the surface of the soil kept free from vegetation was very different from what the result would be if vegetation were growing on the surface. The experiments carried on at Nash Mills, at first by Mr. Dickinson and afterwards by Dr. John Evans, from the year 1840 up to 1884, showed that 46 per cent. of the rain falling on the surface percolated through three feet of the ordinary soil of the district, with grass growing on the surface, in the winter, and 4 per cent. only in the summer, showing a difference of 42 per cent., and an average of 25 per cent. per annum. That showed practically that if we had vegetation on the surface, we must depend upon the winter rainfall for our water-supply. Experiments made for 22 years at Lea Bridge with gauges three feet deep, with grass growing on the surface, gave a percolation of 28 per cent. throughout the year. There, also, the percolation was very much greater in the winter than it was in the summer. The difference between these results and those arrived at by Mr. Mawley was evidently due to vegetation, so they could not at all consider that on an average anything like the amount which percolates through Mr. Mawley's gauges gets to the underground water-level. It had been assumed

that 3 feet was sufficient depth to gauge the water which gets beyond the reach of capillary action and possible subsequent evaporation from the surface. But that was not at all the case. They had not a greater authority on this subject than the late Professor Ansted, and he made experiments which showed that water was actually drawn up through chalk by capillary action a distance of 16 feet, and he came to the conclusion that there was no practical limit to the depth from which water might be thus drawn up. Much water which percolates through the surface-soil in the winter was very probably—and experiments had been made which tended to show it—drawn up again in the summer when the ground gets dry; the continual capillary action bringing the water to the surface to be evaporated, and not only evaporated, but absorbed by vegetation. This showed one important point which had not been thoroughly considered, and that was, how far the moisture necessary for the success of agricultural operations on the Chalk, in the summer, in dry times, to supply the amount required by growing crops, is dependent upon the winter rainfall rising by capillary action. No doubt a great amount was so drawn up from a considerable depth and absorbed by vegetation. Another point was the extent, in Hertfordshire, of woods. It was well known that in a wooded country, by evaporation from the leaves of trees cooling the atmosphere and thus causing condensation of vapour, there is a greater rainfall than in a treeless country,—that more rain falls where there are many trees than where there are few trees. But a series of experiments were made at one time which proved that an oak tree would absorb more than eight times as much water as fell upon it during the period of its summer growth, showing to what a great extent we are dependent for the favourable state of our crops, and vegetation generally, on the amount of rain which falls in the winter and gets down to the underground reservoir to be drawn up again in the summer. With vegetation, also, he thought that the percolation through a heavy soil would be less than that through a light soil.

Dr. Brett said that the late Rev. James Clutterbuck, who was born at Watford House, where his father, the historian of Hertfordshire, lived, took a great interest in the water question fifty years ago, when he was curate at Watford. He spent much time and labour in taking observations on the level of water in wells, and in studying the geology as affecting water-supply. He might indeed be called the father of hydro-geology, at least in Hertfordshire. He (Dr. Brett) had received many letters from him on the subject. He had one written about ten years ago, when he asked him the best way of increasing the Watford water-supply, which was failing, possibly because the North-Western Railway Company had sunk a well by the viaduct and were taking a large quantity of water, and the brewers also were using a good deal. In that letter, which was dated "June 6, 1881," he said: "I have always maintained that the water in the Chalk is exhaustible, though I may have said that the quantity taken to supply the town of

Watford would scarcely be felt . . . . The rainfall of the last six years has year by year been in excess of the average, giving a total excess of 40 inches. The flood-waters due to this excess find their way into the Chalk on the east bank of the Colne, and thus prevent the exhaustion by pumps being felt, but should the present or any future year be very deficient in rain, then the water in the Chalk to the east would be speedily reduced and the exhaustion would be felt to the west, and the volume of water in the river would be sensibly reduced. I have heard that the North-Western Railway Company expect two million gallons per day from the well near the viaduct—this and the Colne Valley well would probably fail, that is if the Colne Valley Company tries to pump two millions also. The Watford town well should not be bored, but headings should be driven in the Chalk. The Lower Chalk as a rule yields little water, though of course as the boring is deepened the water comes under greater pressure. I should like to know how much water the North-Western Railway Company pumped from their well at the viaduct on an average during last year, and how much they can pump at present. I have been watching for a short water year; come when it will, I think my anticipations will be verified."

2. "Note on the Meteor of the 14th of December, 1890." By the President. (*Transactions*, Vol. VI, p. 194.)

3. "Report on Diseases of Plants in Hertfordshire in 1890." By A. T. Brett, M.D. (*Transactions*, Vol. VI, p. 191.)

4. "On the Poisonous Properties of *Primula obconica*." By A. T Brett, M.D. (*Transactions*, Vol. VI, p. 195.)

5. "Note on Insects building in a Lock." By A. T. Brett, M.D. (*Transactions*, Vol. VI, p. 196.)

6. "Note on a Stoat caught in a Mole-trap." By W. Lewis. (Communicated by Dr. Brett.) (*Transactions*, Vol. VI, p. 196.)

The following papers were taken as read:—

1. "Report on the Rainfall in Hertfordshire in 1890." By the President. (*Transactions*, Vol. VI, p. 179.)

2. "Climatological Observations taken in Hertfordshire in 1890." By the President. (*Transactions*, Vol. VI, p. 187.)

Ordinary Meeting, 20th April, 1891, at Watford.

John Hopkinson, Esq., F.L.S., F.G.S., etc., President, in the Chair.

Mr. Ernest Brunton and Dr. Henry Case were elected Members of the Society.

The following lecture was delivered:—

"Photography Past and Present." By William Coles.

Various experiments were made by Mr. Coles in illustration of his lecture.

Field Meeting, 9th May, 1891.

BENNET'S END, HEMEL HEMPSTEAD.

The brickfields at Bennet's End, between Leverstock Green and Hemel Hempstead, are of considerable geological interest and have been visited by the Society on two previous occasions, on the 17th of June, 1876, under the direction of Dr. (now Sir) John Evans, and on the 18th of May, 1889, under that of Mr. Hopkinson and Dr. Morison. This time Mr. Upfield Green acted as Director, and he has furnished the following account of the meeting, with the accompanying plan and section.

Reaching Box Moor by train the party proceeded across the fields to Elephant Farm, and thence to the lower brickfield marked A on the plan. This as well as the other brickfields in the neighbourhood are situated on a plateau varying from about 440 to 500 feet above sea-level, and they fringe an outlier of the London Clay and Reading Beds, to which reference will be made.

The Brick Earth in pit A is clay of a brownish colour containing few pebbles, and has been cut through to a depth of from 20 to 25 feet, where it changes to a bluish grey clay with many pebbles. The Chalk has not here been reached.

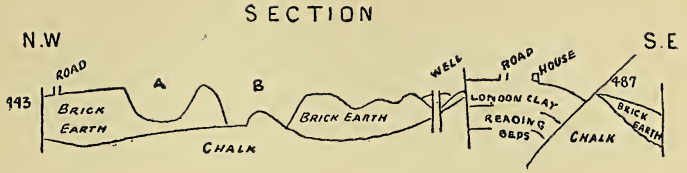
The second pit, B, at a somewhat higher level, presented a very good section. From the surface to a depth of 5 or 6 feet, drift gravel was seen, containing large quartzite and sandstone pebbles with many blocks of sarsen-stone and pudding-stone much rolled. Beneath this, Brick Earth of a reddish colour and of a more sandy nature than that in pit A, laminated in places and traversed by veins of pipe-clay, had been excavated to a depth of from 20 to 25 feet round a boss or head of chalk which was covered by a layer of green-coated, unrolled flints, rolled flints, and flint-pebbles. These heads of chalk are characteristic of the Brick Earth deposits in this neighbourhood, and are found sometimes immediately below the Drift and at other times 20 feet or more below it.

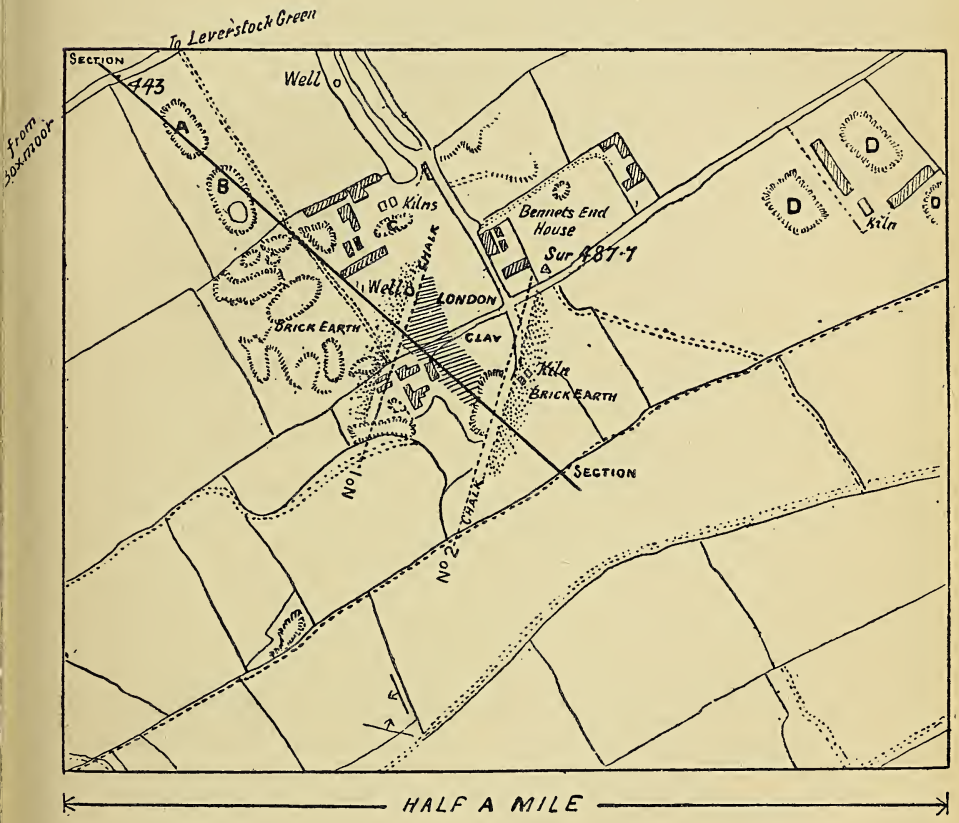
Somewhat to the east, another pit, C, has been sunk to a depth of from 30 to 35 feet without reaching the Chalk.

To the south-east of these pits, along the line No. 1, a ridge of chalk appears, running a few degrees east of north, with a wall on the eastern side dipping at an angle of from 75 to 80 degrees to the east. The surface of this wall is hard, polished and striated, and covered by a layer of laminated, shiny, black clay. Reposing horizontally on this wall, a section is disclosed of about 12 feet of the basement-bed of the London Clay, containing teeth of *Lamna* and other characteristic fossils, and succeeded beneath by a bluish-grey plastic clay of the Reading Beds. The Chalk at the base of these beds had not been reached.

Crossing the road, an old pit at the rear of Tilekiln Farm was visited, which the Director stated had been pointed out to him by Dr. Evans as the spot where the fault referred to by Mr. Whitaker*

* 'Geology of London' (1889), p. 209. See also 'Trans. Watford Nat. Hist. Soc.,' Vol. I, p. xli, and 'Trans. Herts Nat. Hist. Soc.,' Vol. V, p. xxxvii.





PLAN AND SECTION OF BENNET'S END BRICKFIELDS, HEMEL HEMPSTEAD, ON THE SCALE OF 9 INCHES TO THE MILE.

(*Vertical scale of section much exaggerated.*)

had been seen. The direction and dip of this fault are indicated by No. 2 on the accompanying plan and section.

After inspecting pits D, which contain a very bright red loamy clay worked to a depth of about 30 feet and disclosing two pinnacles of chalk, the summits of which were touched about 15 feet below the surface, and noticing a very fine and perfect specimen of a *Paramoudra*, and a block of sarsen-stone showing rootlets throughout it, the members separated, some walking with their President to St. Albans, and others returning through Handley's Dell, with a sight of "Paradise," to Boxmoor Station, and thence by train to Watford.

Field Meeting, 13th May, 1891.

DUNSTABLE AND TOTTERNHOE.

This meeting was held in conjunction with the Bedfordshire Natural History Society, and was under the direction of Mr. Worthington G. Smith, of Dunstable, and Mr. James Saunders, of Luton.

The members of the two Societies drove in brakes from Luton to Dunstable, and on arrival there Mr. Smith conducted them over the Church, explaining the various features of its architecture. Some portions are built of Totternhoe Stone and show much decay from weathering. The fine west front was much admired.

The residence of Mr. Worthington Smith was next visited, and his collection of antiquities was inspected. Much interest was taken in the pre-historic relics which had been obtained from the ruined tumulus on Dunstable Downs.

After partaking of refreshments, kindly provided by Mrs. Smith, the party walked along the old drover's way to the ancient encampment called Maiden's Bower, and, passing over the road which leads near to Totternhoe Knoll, on the summit being reached, Mr. Smith pointed out the rectangular Roman Camp on the south-east side, and the indications of a British village and camp on the north-west side, also the hollow on the top of the knoll where the beacon fires were made.

The party then went to the Cross Keys Inn at Totternhoe, where tea was partaken of in the orchard, after which Mr. Saunders gave an address on the geological features of the district, discoursing upon the position of the Totternhoe Stone in the Cretaceous series, the Melbourn Rock as exposed between Luton and Leagrave, the Chalk Rock as seen south-east of Luton, and the Upper Chalk which caps the hills near Luton. Reference was also made to the effect of the Enclosure Act for Totternhoe parish upon the flora of the district, and Mr. Saunders stated that one boggy field, south-west of the village, which had recently been cultivated, until 1889 was one of the richest spots for native plants, including *Parnassia palustris*, *Menyanthes trifoliata*, *Pinguicula vulgaris*, *Anagallis tenella*, *Orchis latifolia*, *Ophioglossum vulgatum*, etc., and a very rare moss, *Hypnum Sendtneri*, but that all these plants had now been exterminated.

With the exception of the moss, all, he said, occurred in other parts of Bedfordshire, Mr. C. Crouch having found *Pinguicula vulgaris* on Markham Hills, but *Hypnum Sendtneri* must now, he feared, be relegated to the list of extinct Bedfordshire plants. As might be expected this field was also the habitat of numerous Mollusca, which had likewise been exterminated, their destruction being specially noticeable after the first ploughing of the field, as in places the surface was whitened with their dead shells. Amongst them the following species had been collected by his son, Edgar Saunders:—*Succinea putris*, *S. elegans*, *Helix nemoralis*, *H. hortensis*, *H. arbustorum*, var. *rupestris*, *H. hispida*, *H. sericea*, *H. rotundata*, *Pupa umbilicata*, and *Vertigo pygmæa*. The despoiling of so rich a locality for both plants and animals was, he said, much to be regretted, and it was the melancholy duty of observers to note the extinction of native species in this area and also the introduction of foreign ones.

The Totternhoe quarries were then visited, and Mr. Saunders pointed out the Totternhoe Stone *in situ* in the only spot where it is exposed in this neighbourhood. From it he has collected the following fossils:—

CRUSTACEA.

Palæga Carteri.

MOLLUSCA.

Belemnites, sp? (*near* plena).
Nautilus elegans.
,, atlas.
Turrilites Mantelli.
Dentalium (*east*).
Rhynchonella gratiana.
,, Mantelliana.
Terebratula semiglobosa.
Plicatula pectenoides.
Pecten fissicosta.
,, Beaveri.
,, orbicularis.

PISCES.

Cimolichthys striatus.
Otodus appendiculatus.

REPTILIA.

Ichthyosaurus campylodon.

Many birds were in full song, nightingales especially, and some of the party, from Lincolnshire, beyond the northern limit of these birds, heard them for the first time. Prof. Plowright found on the locally-abundant *Carum bulbocastanum* an *Æcidium* which he had not previously met with. The weather was agreeable, and the meeting a very successful one.

FIELD MEETING, 23RD MAY, 1891.

WELWYN, AYOT, AND WHEATHAMPSTEAD.

The members assembled at Welwyn Station, and, under the direction of Dr. Morison and Mr. A. C. G. Cameron, descended the hill to the Hertford road and entered the Tewin Water gravel-pit.

Here Mr. Cameron pointed out that this gravel, which lies upon the Chalk in the valleys of the Beane, the Mimram, and the Lea, is of Mid-Glacial age, and was most probably deposited by the retreating waters of a glacial sea. There was much of it, he said, in this district, and it was generally of considerable thickness. It covered large areas around Hitchin and Stevenage, and there were great expanses of it at Hertford, Hatfield, and on towards Watford.

In places it was overlaid by Boulder Clay, and occasionally there were beds or seams of clay in it, and sometimes of brick-earth. It was largely composed of flints, and it also contained quartz-pebbles, quartzose sandstone, chalk, and fragments of older rocks. Occasionally Jurassic fossils were found in it, derived apparently from the Oxford Clay; and thick beds of sand often occurred in it.

On leaving this pit, the east side of which is now grass-grown, obscuring the section, field-paths were taken across the gravelly land between the Mimram and the Lea. At Woodhall Wood, one mile south of Digswell Junction, the gravel passes underneath the Boulder Clay, which ranges eastward to Cole Green. The clay is one of a number of isolated patches lying south of the main mass, which, in the River Lea catchment-basin, terminates at its tributary the Beane. On the Chalk area the most southerly of these patches is at Bricket Wood; but there are others on the Tertiaries, still nearer to the northern edge of the Thames valley.

At the Woodhall brickyard, which is a very extensive one, clay, sand, and gravel are dug. The pit shows the Mid-Glacial sands upwards of fifty feet thick, in a single vertical section, but a much less thickness of Boulder Clay than is seen at Bricket Wood. This gradually thins from one end of the pit to the other, probably from denudation, as it comes up to the edge of the pit, and the surface of the ground slopes to the south. It rests directly upon the Mid-Glacial sands, which pass down into coarse gravel, dug in places to the Chalk. It is this Boulder Clay which is used for brick-making.

On leaving this pit the fields were crossed to Sherrard's Park Wood, through which a path to Ayot was taken. Chalk has been dug in this wood for centuries, and it is believed to contain extensive underground galleries. Sections of the Reading Beds and the basement-bed of the London Clay exposed in the brickfield near Ayot station should now have been examined, but time did not permit, the train for Wheathampstead being due. On arrival there the members walked to Delaport, where they were hospitably entertained by Mr. and Mrs. Upton Robins, to whom the thanks of the Society were accorded, on the proposition of the President, seconded by Dr. Morison.

After inspecting a gravel-pit in the grounds, the party separated, a few walking to St. Albans with the President, and the majority visiting the Church under the guidance of the Rev. Canon Davys, and leaving Wheathampstead by train.

Field Meeting, 30th May, 1891.

CASSIOBURY PARK, WATFORD.

The members assembled at the principal entrance to Cassiobury Park, and, some driving and others walking, crossed the park to the Swiss Cottage grounds, through which runs the river Gade. Some time was spent here in botanising, and then these grounds were left by the gate in Rousebarn Lane, and the park was

re-entered by the gate just beyond the canal bridge. Leaving it again by the stile near Whippendale, the Whippendale Woods were soon entered, and were searched for interesting plants. The return walk was through the avenue in the far park, over the Navigation Bridge, and across the home park into the Woodwalks, which were left at Temple Cottage, where Langley Road meets the Hempstead Road. The members were then received and entertained at tea by Mrs. James Hopkinson, at her residence, Holly Bank.

The President acted as Director and recorded the rarer plants seen in the course of the walk, which were as follows:—*Dentaria bulbifera*, L., *Vicia angustifolia*, Reich., *Alchemilla vulgaris*, L., *Galium uliginosum*, L., and *Vinca minor*, L.

Permission to drive through Cassiobury Park and to visit the private grounds had been kindly granted by the Earl of Essex. The meeting was numerously attended, and the walk, always an attractive one, was much enjoyed.

Field Meeting, 11th June, 1891.

BROXBOURNE AND HERTFORD.

A small party of the members went by train from Hertford to Broxbourne, and, after inspecting the Alpine and other plants in Messrs. Paul and Sons' Nurseries, walked across the fields to Baas Hill, and by Baas House and the ponds, Carnel's Green, Broxbournebury Farm and Common, Martin's Green, Cow Heath Wood, Monk's Green, and Mangrove Lane, to Hertford.

The walk was chiefly devoted to botanising, and the following is a list of the plants observed, and determined by Mr. R. T. Andrews, the Director of the meeting.

Phanerogamia.

Dicotyledonæ.

Ranunculus repens, *L.*
,, acris, *L.*
,, bulbosus, *L.*
,, Lingua, *L.*
,, Flammula, *L.*
Papaver Argemone, *L.*
Chelidonium majus, *L.*
Nasturtium officinale, *R. Br.*
Cardamine pratensis, *L.*
,, amara, *L.*
,, hirsuta, *L.*
Alliaria officinalis, *Andrz.*
Erysimum cheiranthoides, *L.*
Sisymbrium officinale, *Scop.*
Sinapis nigra, *L.*
,, arvensis, *L.*
,, alba, *L.*
Cochlearia Armoracia, *L.*
Thlaspi arvense, *L.*
Capsella Bursa-pastoris, *Mœnch.*
Viola canina, *L.*
Polygala vulgaris, *L.*
Lychnis Flos-cuculi, *L.*
Melandryum silvestre, *Roehl.*
Cerastium vulgatum, *L.*
Stellaria Holostea, *L.*
,, graminea, *L.*
,, uliginosa, *Murr.*
Spergula arvensis, *L.*
Geranium molle, *L.*
,, Robertianum, *L.*
Ilex Aquifolium, *L.*
Medicago lupulina, *L.*
Trifolium medium, *L.*
,, repens, *L.*
Lotus corniculatus, *L.*
Lathyrus pratensis, *L.*
Orobus tuberosus, *L.*
Vicia Cracca, *L.*
,, angustifolia, *Reich.*
Ervum hirsutum, *L.*

Rubus idæus, *L.*
Fragaria vesca, *L.*
Potentilla Anserina, *L.*
,, reptans, *L.*
,, Tormentilla, *Neck.*
,, Fragariastrum, *Ehrh.*
Geum urbanum, *L.*
Cratægus oxyacantha, *L.*
Heracleum Sphondylium, *L.*
Conopodium denudatum, *Koch.*
Sison Amomum, *L.*
Galium sexatile, *L.*
,, Aparine, *L.*
Anthemis nobilis, *L.*
Leucanthemum vulgare, *Lam.*
Bellis perennis, *L.*
Hieracium Pilosella, *L.*
Myosotis palustris, *Relhan.*
,, intermedia, *Link.*
Veronica officinalis, *L.*
,, Chamædrys, *L.*
,, Beccabunga, *L.*
,, Anagallis, *Scop.*
,, serpyllifolia, *L.*
Rhinanthus minor, *Ehrh.*
Pedicularis silvatica, *L.*
Ajuga reptans, *L.*
Lamium album, *L.*
Galeobdolon luteum, *Huds.*
Glechoma hederacea, *L.*
Thymus Serpyllum, *L.*
Utricularia vulgaris, *L.*
Lysimachia nemorum, *L.*
Plantago media, *L.*
Rumex Acetosa, *L.*
,, Acetosella, *L.*
Polygonum Bistorta, *L.*
Urtica dioica, *L.*

Monocotyledonæ.

Carex acutiformis, *Ehrh.*
,, pendula, *Huds.*
,, axillaris, *Good.*
,, muricata, *L.*
Anthoxanthum odoratum, *L.*
Alopecurus pratensis, *L.*
,, geniculatus, *L.*
Cynosurus cristatus, *L.*
Milium effusum, *L.*
Aira flexuosa, *L.*
Dactylis glomerata, *L.*
Glyceria fluitans, *R. Br.*

Cryptogamia.

Filices.

Pteris Aquilina, *L.*
Asplenium Adiantum-nigrum, *L.*
,, Ruta-muraria, *L.*
Polypodium vulgare, *L.*

Hepaticæ.

Marchantia polymorpha, *L.*
Ricciella fluitans, *R. Br.*

Field Meeting, 14th June, 1891.

ALDENHAM AND BRICKET WOOD.

This was the third Field Meeting in succession the object of which was purely botanical. Miss Selby, the Society's recorder of flowering plants, acted as Director, and under her guidance the members walked from Watford, by Bushey Mill, through the grounds of Otterspool and Aldenham Abbey, and then through Munden Park, to Bricket Wood, where they had tea, returning, some to Watford and others to St. Albans, by train.

Miss Selby reports that *Thalictrum flavum*, L. (not quite in bloom), *Brassica campestris*, L., *Lemna trisulca*, L., and *Carex acutiformis*, Ehrh. (= *C. paludosa*, Good), were gathered at Bushey Mill; that *Adoxa moschatellina*, L., was found at Otterspool; and *Carex glauca*, Scop., on the bank of the Colne at Munden.

Field Meeting, 11th July, 1891.

ST. ALBANS.

The members assembled at the London and North-Western Station, St. Albans, and walked by the River Ver to St. Michael's Bridge, and, crossing the Redbourn Road, up the lane to the gravel-

pits on Townsend Farm, between Osterhills and Bernard's Heath, the President and Dr. Morison acting as Directors.

In the gravel there are large blocks of the Hertfordshire Conglomerate, which appear in some places to be *in situ*, reposing on undisturbed beds of the Reading Series. This point was discussed on the spot, but no definite conclusion was arrived at. The age of the gravel here is also doubtful, for, although it contains quartz-pebbles and a few slightly-worn fragments of derived rocks, they are not sufficiently numerous to make it certain that it is a glacial gravel, and no derived (or other) fossils have been detected in it. The St. Albans outlier of the Reading Beds appears to end here abruptly, for in different parts of the pits these beds occur at the same level as thick beds of gravel.

Bernard's Heath was crossed to the brickfields, where sections of the Reading Beds are more fully exposed, but there was not time for a close inspection of these sections.

The members and their friends were then received and entertained at tea by the President and Mrs. Hopkinson, at their residence, The Grange.

Field Meeting, 17th October, 1891.

BRICKET WOOD.

This, being the last field meeting in the year, was as usual the annual Fungus Foray. The members assembled at Bricket Wood Station and strolled through the wood to the Watford and St. Albans Road, some returning through the wood, some walking to Watford, and others to St. Albans. The meeting was under the direction of the President.

Owing to the very wet weather, and the absence of early frosts, this was an exceptionally good season for fungi, and upwards of 150 species were met with—a larger number than has ever before been found at any Fungus Foray of the Society. It was remarked, however, that several of the usually common species were absent, their place being taken by forms which in most years are but rarely seen. As this was also the case in the previous year, when fungi, owing to the very dry weather, were unusually scarce, it seems to show that different species are differently affected by the weather, some of the commoner species not springing up in very dry weather and some not growing in very wet weather, while both extremes bring out certain forms which are probably rare because they seldom grow in normal seasons.

The species were identified by Mr. George Massee, of Kew, who pointed out the edible forms, stating that they were considered edible chiefly on account of their flavour, several being much superior in flavour to the common mushroom (*Agaricus campestris*), but that all, or nearly all, might be eaten with impunity if mixed up together, well cooked in order to volatise any poisonous matter they may contain, and served up with vinegar, which would neutralise their alkaline properties.

The following is a list of the species collected by the party and determined by Mr. Massee. The species which have not before been recorded for Hertfordshire are indicated by an asterisk, and the rarer forms by a dagger. It will be seen that not only is the list an unusually long one, but also that it adds many species to the Hertfordshire record. In fact it is the most successful foray the Society has ever had.

HYMENOMYCETES.

Agaricus (Amanita) mappa, *Batsch.*
,, ,, phalloides, *Fr.*
,, ,, muscarius, *L.*
,, ,, rubescens, *Pers.*
,, ,, vaginatus, *Bull.*
,, (Lepiota) procerus, *Scop.*
,, ,, rachodes, *Vitt.*
,, ,, cristatus, *Fr.*
,, ,, granulosus, *Batsch.*
,, (Armillaria) melleus, *Vahl.*
,, (Tricholoma) equestris, *L.**
,, ,, sejunctus, *Sow.*
,, ,, resplendens, *Fr.*
,, ,, acerbus, *Bull.**
,, ,, flavo-brunneus, *Fr.**
,, ,, stans, *Fr.*
,, ,, rutilans, *Schaeff.**
,, ,, terreus, *Schaeff.*
,, ,, saponaceus, *Fr.*
,, ,, bufonius, *Fr.**
,, ,, personatus, *Fr.*
,, ,, melaleucus, *Pers.**
,, (Clitocybe) nebularis, *Batsch.*
,, ,, clavipes, *Fr.*
,, ,, phyllophilus, *Fr.*
,, ,, pithyophilus, *Fr.**
,, ,, fumosus, *Pers.*
,, ,, cyathiformis, *Fr.*
,, ,, brumalis, *Fr.*
,, ,, ditopus, *Fr.**
,, ,, fragrans, *Sow.*
,, ,, bellus, *Fr.**†
,, ,, baccatus, *Scop.*
,, (Collybia) radicatus, *Rehl.*
,, ,, fusipes, *Bull.*
,, ,, maculatus, *A. and S.*
,, ,, butyraceus, *Bull.*
,, ,, confluens, *Pers.*
,, ,, cirrhatus, *Schum.*
,, ,, dryophilus, *Bull.*
,, ,, clavus, *Bull.**
,, (Mycena) purus, *Pers.*
,, ,, pelianthinus, *Fr.**†
,, ,, rugosus, *Fr.*
,, ,, galericulatus, *Scop.*
,, ,, polygrammus, *Bull.*
,, ,, alcalinus, *Fr.*
,, ,, ammoniacus, *Fr.*†
,, ,, filopes, *Bull.*
,, ,, hæmatopus, *Pers.*
,, ,, sanguinolentus, *A. & S.**
Agaricus (Mycena) galopus, *Fr.*
,, ,, epipterygius, *Scop.*
,, ,, vulgaris, *Pers.**[*Mass.**†
,, ,, olivaceo-marginatus,
,, (Omphalia) pyxidatus, *Bull.**
,, ,, umbelliferus, *L.**
,, (Pleurotus) lignatilis, *Pers.**
,, ,, applicatus, *Batsch.**
,, (Pluteus) cervinus, *Schaeff.*
,, (Entoloma) jubatus, *Fr.**
,, ,, sericellus, *Fr.**
,, ,, sericeus, *Bull.*
,, ,, nidorosus, *Fr.*
,, (Clitopilus) prunulus, *Scop.*
,, ,, orcella, *Bull.*
,, ,, cancrinus, *Fr.**
,, (Leptonia) lampropus, *Fr.*
,, (Nolanea) pascuus, *Pers.*
,, (Eccilia) atropunctus, *Pers.**†
,, (Claudopus) byssisedus, *Pers.**
,, (Pholiota) radicosus, *Bull.**
,, ,, squarrosus, *Müll.*
,, ,, spectabilis, *Fr.**
,, ,, mutabilis, *Schaeff.*
,, ,, unicolor, *Fr.**
,, (Inocybe) pyriodorus, *Pers.**
,, ,, scaber, *Müll.**
,, ,, rimosus, *Bull.*
,, (Hebeloma) fastibilis, *Fr.*
,, ,, sinapizans, *Fr.**
,, ,, crustuliniformis, *Bull.*
,, (Flammula) gummosus, *Lasch.**
,, ,, inopus, *Fr.**†
,, ,, sapineus, *Fr.**
,, (Naucoria) melinoides, *Fr.*
,, ,, pediades, *Fr.*
,, ,, semiorbicularis, *Bull.*
,, (Galera) tener, *Schaeff.*
,, ,, hypnorum, *Batsch.*
,, ,, mycenopsis, *Fr.**†
,, (Tubaria) furfuraceus, *Pers.*
,, (Crepidotus) mollis, *Schaeff.*
,, (Psalliota) silvaticus, *Schaeff.*
,, ,, sagatus, *Fr.**
,, (Stropharia) æruginosus, *Curt.*
,, ,, albo-cyaneus, *Desm.**
,, ,, inunctus, *Fr.**
,, ,, squamosus, *Fr.*
,, ,, thraustus, *Schulz.**
,, ,, Worthingtoni, *Fr.**
,, ,, stercorarius, *Fr.**
,, ,, semiglobatus, *Batsch.*

Agaricus (Hypholoma) sublateritius, *Fr.*
,, ,, capnoides, *Fr.**
,, ,, fascicularis, *Huds.*
,, ,, velutinus, *Pers.*
,, ,, Candolleanus, *Fr.*
,, ,, hydrophilus, *Bull.*
,, (Psilocybe) ericæus, *Pers.*
,, ,, spadiceus, *Schaeff.*
,, ,, cernuus, *Müll.**†
,, (Panæolus) fimicola, *Fr.**
,, (Psathyrella) gracilis, *Fr.*
,, ,, attenuatus, *Fr.**
,, (Psathyra) bifrons, *Berk.**†
Coprinus lagopus, *Fr.**
,, atramentarius, *Fr.*
Cortinarius cyanopus, *Fr.**
,, fulgens, *Fr.**
,, elatior, *Fr.*
,, torvus, *Fr.**
,, paleaceus, *Fr.**
,, acutus, *Pers.*
Paxillus involutus, *Batsch.*
Hygrophorus cossus, *Sow.*†
,, niveus, *Scop.*
,, fornicatus, *Fr.**†
,, obrusseus, *Fr.*
Lactarius torminosus, *Schaeff.*
,, blennius, *Fr.*
,, trivialis, *Fr.*
,, pyrogalus, *Bull.*
,, Capsicum, *Schulz.**†
,, piperatus, *Scop.*
,, vellerius, *Fr.*
Lactarius aurantiacus, *Fl. Dan.**
,, rufus, *Scop.**
,, glyciosmus, *Fr.*
,, fuliginosus, *Fr.**
,, camphoratus, *Bull.**
,, subumbonatus, *Lind.*
Russula emetica, *Fr.*
,, nigricans, *Fr.*
,, adusta, *Fr.*
,, azurea, *Bres.**†
Marasmius oreades, *Fr.*
,, Rotula, *Fr.*
Polyporus versicolor, *Fr.*
,, vaporarius, *Fr.*
Dædalia quercina, *Fr.*
Clavaria inæqualis, *Müll.**
,, fumosa, *Pers.**
,, vermiculata, *Scop.**
,, fragilis, *Holmsk.*
Calocera cornea, *Fr.**

GASTROMYCETES.

Lycoperdon saccatum, *Pers.**
,, gemmatum, *Fr.*
Scleroderma verrucosum, *Pers.**
,, vulgare, *Fr.*

ASCOMYCETES.

Xylaria Hypoxylon, *Grev.*
Peziza aurantia, *Fr.**
,, virginea, *Batsch.**

MYXOGASTRES.

Stemonitis ferruginea, *Ehrh.**

The following species of Hymenomycetes were found in the morning at Watford House and in Cassiobury Woodwalks by Dr. Brett and Dr. Eteson, and were named by Mr. Massee.

Agaricus (Lepiota) procerus, *Scop.*
,, (Tricholoma) personatus, *Fr.*
,, (Clitocybe) nebularis, *Batsch.*
,, (Collybia) dryophilus, *Bull.*
,, (Mycena) galericulatus, *Scop.*
,, (Pholiota) squarrosus, *Müll.*
,, (Stropharia) æruginosus, *Curt.*
Coprinus comatus, *Fr.*
Lactarius subdulcis, *Fr.*
Russula emetica, *Fr.*
,, nigricans, *Fr.*
Boletus chrysenteron, *Bull.*
Marasmius personatus, *Fr.*
Stereum hirsutum, *Fr.*

TRANSACTIONS

OF THE

HERTFORDSHIRE NATURAL HISTORY SOCIETY.

I.

ANNIVERSARY ADDRESS.

FIELD SPORTS AND THEIR BEARING ON THE NATIONAL CHARACTER.

By the President, the Right Honourable the Earl of Clarendon.

Delivered at the Annual Meeting, 21st of February, 1890, at Watford.

Ladies and Gentlemen,—

When I look at the list of past Presidents of the Hertfordshire Natural History Society and the prominent position which they occupy in the world of science and art, I must confess that I approach the task which falls to my lot to-night with a considerable amount of diffidence, for I am alive to the fact that, whereas those who have preceded me in the important office I hold have been able to treat and to diagnose the subjects they have chosen for discussion in a philosophical manner and with a full knowledge of all the matters relating to and which bear upon the particular topic they may have selected, I can offer you nothing to-night save a few practical remarks which are the offspring of a participation in and observation of the field sports and pastimes of England.

The great Duke of Wellington is supposed to have said that the battle of Waterloo was won in the playing-grounds of our public schools and in the hunting-fields of Great Britain, and although neither proficiency in the games of cricket and football, nor a thorough knowledge of "venerie," is of itself likely to produce in after life a skilful tactician in war, yet it undoubtedly creates that spirit of emulation, that desire to excel, that promptitude in action, that fertility of resource and the application thereof to the exigencies of the moment, and that determination to overcome obstacles, which have in so many cases led to the Field Marshal's bâton and the

laurel-wreath of the victor. While this is undoubtedly true of those whose lives are passed or to be passed amid the "pride, pomp, and circumstance" of war, it is equally applicable to those whose career lies in the prosecution of more peaceful employments.

It will be my object to-night to attempt to demonstrate that our national sports have an influence, and a salutary influence, upon the national character; for as there are "sermons in stones" so is there a very series of homilies in what is called the brute creation, at all events to those who have the opportunity, and take advantage of that opportunity, of making close and practical observation of the habits and customs of the animals which minister to their sport or which they may chance to meet in their daily walks abroad. Far be it from me to deny the superiority of man over the beasts of the field. It is of course a truism to say that man is possessed of soul, of intellect, and of the powers of reasoning, but it is when these are misused or left to lie fallow that one appreciates all the more the glorious gift of instinct implanted in animals. "Comparisons are odious," but it cannot be denied that the virago who neglects her children, and the drunken sot who beats and starves both wife and child, have much to learn from the birds and the beasts, who, though lower in the scale of creation, tend their offspring with infinite and loving care, and often indeed even risk their lives in their defence. It may be that want of education and refinement, evil communications, and pernicious example, stand in the way of many of the so-called "lords of creation" and prevent them from duly performing those duties unto which it has pleased God to call them, but if this be so, the fault lies with man himself and his misuse and neglect of the talents given to him. England is not Utopia. We have not yet arrived at the millennium, but, until legislation or education attain that desirable end, those amongst us who have been weighed in the balance and found wanting will do well to imitate the example of the brute creation, at least in cases where soul and intellect have no place.

In the heat of the chase it is hardly to be expected that the sportsman can take other than cursory observation of the animals which may form his quarry, and it is only in his quieter and more sober moments that their habits and customs become food for reflection. True it is that some so-called sportsmen indulge in their daily pursuits apparently with a view only of boasting of the number of the slain or of the perilous obstacles which they may have successfully overcome in the hunting-field, but the true

sportsman is invariably a close observer of nature. To all students of natural history the name of Lord Walsingham is familiar, and I speak from personal knowledge when I say that amongst sportsmen he is *facile princeps*, and although hecatombs of the birds and the beasts of the field are yearly sacrificed to his unerring tubes, yet there does not exist any one who is a closer observer of their habits, who has written with greater or more practical knowledge concerning them, or who has himself made more interesting and valuable collections of the British Fauna.

It has been said that almost all sports and pastimes are either cruel, dirty, or dangerous. However this may be, and it cannot be denied that there is a substratum of truth in the remark, there are two sides to the picture, and it is my province to look to-night to that side which presents itself in the fairer and brighter light, and to attempt to show that it is not a murderous instinct nor a love of slaughter which actuates those who take part in the sports of the field, the pursuit of which has tended in no inconsiderable degree to make Englishmen manly, brave, and self-reliant. Can it be supposed for one moment that the breathing living representation of the "Monarch of the Glen" or of the "Children of the Mist" could have been limned by one who had taken no part in compassing their downfall and death? Is it not rather that the accurate knowledge of detail and the faithful portraiture of nature, which in Sir Edwin Landseer's case gladdens the eye and thrills the heart of the deer-stalker, is the outcome of a personal participation in a pursuit the many incidents of which his brush has immortalized? Could that high priest of Diana, the king of sporting novelists, Whyte-Melville, have ever narrated those "moving incidents by flood and field" which warm the life-blood and stir the pulse of every fox-hunter, were it not that he loved the sport so well concerning which he wrote with such fire and vigour, and in the midst of which he met with his untimely end? Is it not the case that many an English fireside is brightened by the perusal of the masterly efforts of the great novelist's pen, many a British home rendered happier and cheerier by the contemplation of the faithful records of the great painter's art? Who is there who is not edified by and interested in Charles Dickens' description, in the immortal 'Pickwick,' of the 1st of September, and of how the young partridge, ignorant of his fate, struts about the fields in the finnicking coxcombry of youth; and who that would not believe that the spirit which characterizes his narrative is the result of personal observation and participation?

As in all other matters, so in those pertaining to the chase, it is only experts and those who have practical knowledge who can commit to canvas or to paper anything that is worthy of being handed down to posterity. A vast amount is written on these subjects that is misleading as well as ridiculous. I read in a newspaper once on the 1st of September that that day was the feast of St. Partridge, and that in the stubble and turnip fields the "crack of the rifle" would be heard all around! All bullets have their billets, but if they found them in the heart of the partridge there would be but few specimens of that succulent dainty to grace our tables! Many a time and often have articles appeared in the daily journals characterizing the field sports of England as massacre, but if massacre it be, it is one which requires both practice and skill, and if the writers of such articles took post behind a hedge with a northerly gale blowing, during the sport of partridge-driving, which they dub as un-English and unsportsmanlike, I, for one, should not very strongly object to being the partridge! These and similar diatribes are born of ignorance and a maudlin sentimentalism, which one could hardly believe could be evoked by the discussion of a pastime which requires nerve, skill, combination of hand and eye, and experience, and the treatment of which had best be left to those who possess these qualifications.

I should range over too wide a field were I to discuss the attributes and the habits of all such animals concerning which I may have a little practical knowledge. I purpose therefore making a few remarks concerning the partridge and the fox, two kinds of animals which have a closer connection than one of them at least would wish, but both of whom are the *raison d'être* of our principal national sports; and the narration of some few incidents which have come under my personal observation may not be out of place.

I am confident that I shall be in touch with my audience when I say that there is no purer or better method of passing one's leisure hours than to ramble in this our lovely county of Hertfordshire, "far from the madding crowd," and away from the busy hum of men, Nature one's sole companion, and one's heart filled with gratitude to Providence for the senses of sight and smell, gratified as they are in spring and summer at every step one takes. And so it was that one July morning I chanced to peer over a hedge not one hundred miles from here, when up sprang a hen partridge with her newly-hatched brood. After flying a short distance into the field she stopped and came back running on the ground with her wings

and beak open till she was almost at my feet. I must confess that I was not much terrified and should have had but little difficulty in repelling the attack, but what filled me with astonishment and admiration was that a bird naturally so wary and timid should, by reason of motherly instinct and protective love of her offspring, have even approached man, her deadly foe, and I could not resist comparing this brave onslaught, made only on behalf of her brood, with the precipitate flight which, on the approach of the enemy, she and they some months later would take, when they would no longer need her protection. On another occasion, as I was walking in the middle of a field about the same time of year, I startled a covey of partridges. The young ones were just able to fly, but one of the parent birds kept close to me, flying round me near the ground, uttering its shrill cry, and trailing one of its wings with a view of inducing me to believe it was wounded and so to distract my attention from its young family until they should be out of danger. In the human race we know full well that the loving mother is ready to brave danger, disease, and death itself, for the sake of her child, but what are we to say of this God-given instinct in the brute creation, save that it is marvellous in our eyes and that it is so deep that it passes our understanding! It may not be generally known that the male partridge is the most loving, domestic, and dutiful of consorts. He takes an equal share with his partner in the onerous duties of incubation, and I have myself watched day after day the hen bird leaving her nest in order to procure necessary sustenance, and her mate running or flying from a distance to relieve her in her sedentary duties; moreover, when the brood is hatched, both the parents are equally assiduous in their love, care, and protection of their young. It is a well-known fact that should the weather be unpropitious on the day of hatching, one or other of the parent birds will sit on the nest till the storm is past and there is no longer any danger of the young birds being washed away by the torrents of rain which sometimes visit us during the summer months. On another occasion, just as I was emerging from a wood, I saw about 300 yards away a covey of partridges feeding in a field. After watching them for some time I saw a fox approaching them, and, although he passed within a few yards, their instinct told them that at all events at that time one of the deadliest foes to their race meant them no harm, for they hardly moved out of his way; but when I showed myself, and man appeared on the scene, even though at this great distance, up went

their heads and they immediately took to hurried and terrified flight. One of the best proofs of the family feeling of partridges is that, of the number of birds which roost on the ground, and their name is not legion, they, together with the grouse and ptarmigan, herd in one mass, their contiguity, doubtless, inspiring them with a sense of security against nocturnal marauders.

Buffon states that there are three species and one variety of partridge, but with two only of these are we, in this country at least, concerned—the grey, and the red or red-legged partridge, or what I believe to be erroneously called the French partridge. The character of the two species is widely different, for while the grey is one of the pluckiest and hardiest of birds, its congener the red-legged kind is quite the reverse, and I have with my own hand captured the latter sort on the ground after a flight of a very few hundred yards. My reason for stating that the red-legged is wrongly termed the French partridge is that amongst the number brought to the bag during "*chasses*" in France at which I have assisted, I have not discovered one of the sort, in fact, the sum total was made up entirely of *perdrix grise*, the grey species, or what is commonly called the English partridge. As regards their edible properties, the latter is infinitely superior, while the flesh of the red-legged partridge is flabby and insipid and requires the master-hand of the *chef* to render it fit for the table. There is a curious distinctive mark, apart from the plumage, between the two kinds of partridges. The red species has at the end of the first year an excrescence on its legs just below the bend of the hock; after two years a double growth takes place, and so on, acting as it were like a record of its age, in the same manner as the rings in the trunk of a tree are supposed to enumerate the years of its growth.

The partridge is by nature an exceedingly wild bird and one which it is almost impossible to domesticate, although I have seen in the county of Suffolk a horde of about forty frequent the neighbourhood of a large house and actually feed out of one's hand, but they seldom, if ever, lay eggs when confined in aviaries.

I cannot say whether or no my experience tallies with that of my brother sportsmen in Hertfordshire, but either owing to the gravelly, flinty soil, or from other causes, I have found the partridges of this county more difficult of approach than those of any other county or country, and accurate must be his eye, stalwart his frame, and skilled his marksmanship, who wishes in this neighbourhood to make a creditable return by the end of the day.

Sceptics may argue that if so much interest attaches to the little brown bird, and there is so much to be learnt from its life and habits, why all this time, trouble, and expense in its destruction? Suffice it here to say that if a pursuit of this nature died out of the land, the sportsman would lose a health-giving pastime, the naturalist a means of close and minute observation of an interesting animal, and the gourmand a succulent dainty; while as to the plea of cruelty, we are a carnivorous nation, and a daily slaughter of thousands of animals for our use takes place, which must of necessity be accompanied by a certain amount of cruelty, but comparison may very fairly be made between the breechloader and the pole-axe, and is decidedly in favour of the former if deftly handled.

The field sports of England are a pastime and not a profession, and the people would "imagine a vain thing" did they regard them in any other light than that of a recreation and a relaxation from the more serious and important duties of life, but it is that very relaxation which freshens the mind while it invigorates the body. Mankind is apt to go to extremes, and, were it not for these healthful recreations, it is possible, at all events as regards those who have leisure, that an unbridled indulgence in enervating debauches might supervene, which ere now has led to the decline and fall of empires. There is such a thing as the "business of pleasure," but it is one in the conduct of which a large number of the wage-earning classes is employed, and to which both capital and industry is applied. Every one in this world has a path of duty mapped out either by himself or others, and, in this "business of pleasure," duty may be performed or neglected as the case may be equally with the other callings and avocations of life. In view of the fact that there are thousands of our fellow creatures employed as game-keepers, watchers, huntsmen, and grooms, whose qualifications for other than sporting employments are *nil*, if they were thrown upon their own resources by the cessation of sport, there would be a material addition to the annals of crime and drunkenness, of which the want of employment is often the cause. In connection with this business of pleasure there are thousands upon thousands of acres in parts of the British Isles which are devoted to sporting purposes only, and could be utilized in no other manner, and who that has penetrated the lonely fastnesses, the glens and corries of bonnie Scotland, the home of the red deer, the blackcock, and grouse, shall say that those who are employed in their preservation and protection are not benefited by sport and by those to whom

sport is dear, and would find it impossible to maintain life under any other condition? It is not long since a Bill bearing the title of "Access to Mountains" was introduced in the House of Commons, purely on philanthropic grounds, and with a view of ameliorating the condition of the Highlanders, and some idea was entertained of the possibility of reclaiming the heather-clad hills of Scotland and of bringing the plough to bear upon her uncultivated wilds. No doubt there arose in the mind's eye of the philanthropist visions of peace and plenty, prosperous homesteads, and smiling fields of waving corn, but these are the dreams of a disordered brain, for reclamation in many of these parts is absolutely impracticable, and even where possible would occupy too lengthy a period of time and absorb too large an amount of capital. Supposing, too, that the transformation-scene took place, and trade and agriculture were introduced where heretofore sport only had flourished, would it be possible to transform the Highlander into a husbandman, or the gillie into a grocer? It is hard to believe that legislation of this nature would in any way benefit those classes for which it was intended, or that they could be successful in any other *métier* than that to which their lives, their characters, and their associations have accustomed them. In plain and broad English, it would be impossible for them to get their living in any other way; like Othello, their "occupation would be gone," and even if they did not live in idleness they would be drawn to the great cities, already over-teeming with population, and thus accentuate the very evil we desire to avoid, and complicate the very question which is exercising the minds of our statesmen. All legislation is intended for the greatest good of the greatest number, for the benefit of the poor and of those who are unable to assist themselves, for the repression and extinction of crime in its varied forms; but an enactment of this kind is theoretical and visionary, and as such should not commend itself to those who are at the helm of the ship of state and who guide the destinies of the nation. Nothing can be intrinsically sounder than that those of our fellow-countrymen who have the leisure, the inclination, and the funds at their disposal should have every possible opportunity offered them of improving their minds and preserving their health, but by a parity of reasoning nothing can be more unsound than that they should do so at the expense and to the detriment of vast numbers of their fellow creatures.

I have now to deal with the fox, the other animal which I have chosen for discussion. Nobody knows better than myself the

predatory habits of these wily animals, for nobody has suffered more from them, but many offences are laid at Reynard's door with which he cannot fairly be charged. I remember once a mighty hunter, whose place, alas! knows him no more, telling me of what happened to himself. His shepherd came to him and informed him that a fox which was in the habit of prowling round the sheepfold committed nightly depredations on the lambs. His master placed a gun in his hands with these words: "If he comes to-night, shoot him!" The shepherd, knowing how strictly foxes were preserved on the estate, was somewhat astounded, but did as he was bid. The usual worry took place that night, the gun was discharged, but it was the sheep-dog and not the fox which was brought to bag! I was once told by an Irish landlord that a tenant of his own had come to him and demanded compensation for the loss of his bull. My friend naturally inquired the reason of the animal's death, and was much surprised to learn that it had been frightened to death by a fox barking at it. We have yet to learn that a bull is of such a timid and weakly nature as to be frightened out of its existence in this fashion! A fox is certainly an exceedingly mischievous animal, but it cannot be satisfactorily proved that lamb is its favourite food, and he certainly never frightened a bull out of its life. The dish which suits his taste best is rat, and I once saw a fox kill a rat in the following way. The latter apparently knew what was about to happen, for he showed fight—or his teeth—which is the same thing. The fox got nearer and nearer until he could place his head within a few inches from the rat. One lightning snap of the gleaming tushes, a faint crackling sound, and all was over!

Respecting tame foxes, as of course they are akin to the canine race it is by no means a difficult matter to domesticate them, and last year there was within a few miles of this spot one who would jump on to a chair and sit at his master's side, and who invariably accompanied him in his walks abroad. I should not myself, however, for olfactory reasons, care to possess such a pet. I have myself led one out in a chain for a walk, but this particular animal was of a somewhat ferocious disposition, and would allow no liberties to be taken with him except by his mistress, to whom he was devoted. I have watched him for hours. He was chained to a kennel placed in a yard where poultry was kept, and one day I saw him overturn the receptacle which contained his food, within the limits of his chain, in order to attract and make a meal of the unwary fowls.

There is a great difference of opinion as to the number of which a litter of cubs is composed. Experts tell us that the number never exceeds five, or at most six, but I knew of two litters this year, one of seven and another of eight. I can vouch for the truth of this statement, for they were born and bred on my own place, and I have counted them and watched them play at the mouth of the earth. Such a large family as eight, however, is of rare occurrence. Some years ago I did see eight cubs together outside an earth, but these were palpably two separate families of four, both being nurtured by the same mother, and that this was the case was proved by the discovery a short time before of a vixen fox hard by with a trap on her leg and *in articulo mortis*. A near neighbour of ours once recounted a touching incident connected with a fox. The mother, who was bringing up a young family, either died or was killed, and the dog fox, as far as he was able, performed the maternal duties, foraged for his children, and apportioned their food, but the woe-begone appearance which his knavish countenance presented, and the piteous whines to which he gave vent from time to time, told but too plainly how keenly he felt his loss.

Foxes are exceedingly fleet of foot, and I have seen a fox and a hound start from a covert in close proximity, each going at topmost speed, and at the end of about 300 yards the fox was 60 or 70 yards ahead; in fact were it not for the condition of one and the want of it in the other the fox would almost invariably escape the fangs of his relentless pursuers. It is extraordinary the shifts to which a sinking fox is put, and the crafty wiles he will use in order to escape his fate. I have known foxes to climb trees, ricks, and barns, jump through open and indeed closed windows, take refuge in wine cellars, and even mount staircases and hide under beds. This latter incident took place with the Old Berkeley Hounds last year at Bushey. The hounds had lost their fox, and it was only some little while afterwards that he was seen to emerge from his unusual hiding-place. On one occasion, in the Midland Counties, I saw a fox that had been on foot for a considerable time some 200 or 300 yards in front of hounds; on arriving at the fence which skirted the field, he came back a little way, and crouched down in the open in the hope that the dash of the hounds might carry them over and beyond him, which was just what happened as regards the three or four leading couples, but, alas! he moved, the body of the pack saw him, and what was in the pride of the morning a stout hill fox soon became one hundred "tatters of brown!" I once

knew of a fox which on several occasions had most unaccountably escaped his pursuers, until one day it was discovered that at a certain spot he leapt up on to a broad yew hedge, about three or four feet high, and ran along it for some way as it were in the air, thus leaving no trace or scent behind. When a fox has to cross a river or a stream he very frequently allows the current to take him a long way down the stream, and thus foils the pack by not landing upon the further bank immediately opposite where he entered the water. I may here say that scent is one of the most inexplicable wonders of nature, and those who know best have never been able satisfactorily to account for its absence or presence, but it is certain that a fox's instinct tells him to run down wind as a rule, in order that the scent may be conveyed away from and not towards those in pursuit. I remember once seeing a pack of hounds in the neighbourhood of a pollard willow in the branches of which a fox was crouched. The hounds got beyond the control of the huntsman and whips, broke loose, and surrounded the tree. The fox thinking that flight was the best means of escape, actually jumped on the back of the hounds, gave another spring, and after a half-hour's chase, to the delight of all the sportsmen, lived to run another day.

I could lay before you countless incidents of the chase, but time hardly permits of my doing so. I have already said that mankind has much to learn from the brute creation, but it must be confessed that in the case of the fox the example is one to be avoided and not to be imitated, for except as regards maternal instincts, which are strongly developed, this animal is noticeable particularly for its low cunning, its wanton destructiveness, and its thievish propensities, and therefore observation of its habits is less likely to have a beneficial effect on character than the method employed for its pursuit and capture.

From the remote days of mythology down to the present more civilized epoch the love of the chase in all its varieties has been a component part of national character. To some nations even now this sport is a necessity and a means of livelihood, but that is not the case in England, where our multifarious occupations and trades give us the wherewithal to obtain the necessaries of life. The weapons, the horses, the whole panoply of the chase which satisfied the requirements of our forefathers would be of little practical use now. We live now-a-days at a great rate, and everything is done, so to speak, by electric telegraph, but whether with those who

revel only in a forty minutes' run on the grass without a check, or those who prefer the more protracted delight of seeing hounds unravel yard by yard the intricacies of the line, the breast of almost every British subject is permeated by an enthusiastic adoration of the greatest of our British sports. I have known men who have never bestridden a horse and who are ignorant of the A B C of "venerie," who yet take the greatest interest in the hunt, and offer it the most continuous and liberal support, and I have met but one man in my life who had the hardihood to avow that he disliked hunting, and we could hardly count him, as he was a banker, and considered the pursuit of wealth more exciting and absorbing than that of the fox. Nobody but those who are behind the scenes know the amount of damage, direct and indirect, which in some places the fox-hunter's best friend, the agriculturist, has to tolerate, and the greatest care should be taken by all sportsmen to avoid unnecessary riding over fields and fences, and the greatest liberality should be displayed in the satisfaction of such reasonable claims for damage as he may proffer. It is sometimes said that were hunting to be discontinued the farmer would be a loser, and when one takes into consideration the number of hunting establishments maintained, it is true that there is a very extensive market for the requisite hay, straw, oats, peas, and beans, in fact the stock-in-trade of the agriculturist, but even were hunting to be disestablished, there still would be an outlet for agricultural produce. I do not consider that this is the main cause for which the farmer extends his sympathy and support to fox-hunting. I hold rather that as an Englishman it is his pride and pleasure to countenance an English pastime, and even where he does not take an active part in the sport himself, he looks with a favouring eye on those who do.

In considering the fox and his attributes one must of necessity deal with the adjuncts and accessories of the venatic drama in which he plays the leading part, and here I must plead guilty to being an enthusiast, and as such can hardly expect that your opinions are entirely in agreement with my own, but enthusiasm is not detrimental to character, and where it exists is certain to make itself felt in all and every pursuit and duty of life. It is at all events of greater value than its converse, which may best be described by the French terms "*insouciance*" and "*laisser aller*," which it must be confessed are not characteristics of the busy, bustling Briton. But whence comes that enthusiasm which in this matter is displayed from the cradle to the grave? Why is it that

the baby in arms crows with delight as the pageant of the chase sweeps through our country villages? Why the death-bed request of the famous huntsman that he might once more and for the last time hear the maddening "view holloa" which proclaims a fox on foot? It is that the spirit of the chase is nascent in the one, and has never been lulled to rest in the other. It is because we in this nineteenth century are just as ardent worshippers at the shrine of Diana as those of old, and because love of the pastime is part of the national character. It is because there is romance in the stride of the gallant horse, poetry in the impetus of the fleeting hound. It is the pluck, nerve, dash, and endurance which are requisite to surmount the obstacles to be encountered; it is the strategic skill, the knowledge of the craft, the opposing forces of man's mind and the brute's instinct, and the friendly rivalry between man and his brother man, to which the ecstasy of the fox-hunter owes its birth. It is not only humane feelings and unwillingness to deal death and destruction amongst the pack as it crosses the railway which causes the engine-driver to stop his train, but it is partly a desire that he also may be a witness of the chase, which he regards with longing, wistful eyes as it sweeps out of his sight. Take again the well-known case of the ploughman at the plough, who, unable to resist the attraction, and regardless of the consequences, unyoked one of his horses and joined in the mad revel! Let us hope that he did not unduly suffer for yielding to an impulse which was inborn and stronger than he could bear.

In this world cause and effect regulate all things. Effect is, *ipso facto*, a change from the *status quo*. It follows, therefore, that a pursuit conducted as this, *con amore*, must have some effect, beneficial or the reverse. It cannot be that the freemasonry of the hunting-field, the health-giving, health-restoring occupation, and the employment of labour where as much integrity, application, skill, and enthusiasm is practised as in other careers, can have a baneful effect, either on mind or body; but in this as in all other things there must be moderation. Drones there are as well as bees. Virgil tells us truly that there exist "*fruges consumere nati*," those that are born to consume and not to produce the fruits of the earth; but with the butterflies of existence who devote their whole lives to sport or pleasure and who neglect the more serious duties which must fall to the lot of every man, we have not to deal, and my remarks refer only to those who renovate and restore, by occasional relaxation, the energies which thought or

labour has impaired. There are not wanting instances, indeed I have known them myself, of the fairer sex apportioning their lives between the sports of the field and works of mercy and charity. These have I often seen "witching the world with noble horsemanship," and holding the pride of place in the hunting-field with all comers; and who shall say that their ministrations to the sick and needy were not the tenderer, their zest for the labour of love the greater, for occasional indulgence in the sport which is graced by their presence? I have seen soldiers, sailors, statesmen, lawyers, artists, and poets, upon whom the mantle of Nimrod has fallen. Who can deny that their intellect is the sharper, their wit the clearer and keener, by a seasonable following of the noble craft? Those who "sit at home at ease" perhaps hardly recognize that there is a certain amount of danger inseparable from the crossing of a strongly-enclosed country, but with a well-bred, well-bitted, well-conditioned horse the danger may be reduced to a minimum even where the ox-fence grins, the bull-finch is black, thick, and forbidding, and the brook broad and unfathomable; but it is this very element of danger which lends an additional charm to the chase. I remember once a famous sportsman, the scion of a noble house celebrated in sporting annals, telling me he should not care for hunting unless it were dangerous. Surely then to encounter and successfully to overcome danger must count for something in influence on character. Surely the powers of endurance both in man and beast which it is necessary to put forth are not without a lesson which may be taken to heart under other circumstances. In a neighbouring hunt I used to see once a week a small boy on a small donkey, and however long and severe the run, however spacious the pastures and formidable the fences, both boy and beast invariably turned up, more power to them both, at the termination of the hunt. Is not this a token of character and determination which must make its mark upon the youth's life and career? He must have been one of those—

> To whom nought comes amiss—
> One horse or another, that country or this;
> Who through falls and bad starts undauntedly still
> Ride up to the motto, "Be with them I will."

The Spartans of old used to expose their children on the mountains to test their hardiness, and to secure the "survival of the fittest," and so to perpetuate a sturdy, stalwart, healthy race. In these latter days the sons and daughters of England strive to attain the same end by passing a large portion of their lives out of doors,

and although it is just possible that by "sitting on one's stool and never going to sea" one may become "ruler of the Queen's Navee,"—that there may be mighty minds in puny and sickly frames,—yet it certainly is more probable where intellect and physique exist, that they have been inherited, and more likely that they will be handed down to posterity. And if by this means we secure or maintain that great desideratum, health, we shall also command its concomitant—contentment, without which it is impossible that life should be either pleasant or useful.

It savours somewhat of an empty boast to say that an Englishman can compete successfully with three or four of any other nation, although it is said that an Irish soldier in the Crimean war, who brought in three Russian prisoners, in reply to an inquiry how he had captured them, answered: "Sure I surrounded them." Still, I have always thought and shall always think that he is more than a match for any *one*, and that this is the result of his never knowing when he is beaten, from the stout heart which never quails when face to face with danger, and from the stamina and pluck which athletic pursuits from generation to generation have engendered and fostered.

Ladies and gentlemen, I hardly hope to have amused, much less to have edified you; my ideas concerning the chase, its influence, and its effect may be strained, but of this I am confident, that, were it not for the sports of the field, effeminacy and deterioration would ensue, and there might be some truth in the accusation which sometimes even now is hurled against us, that we are only a nation of shopkeepers. Under these circumstances it is to be earnestly hoped that the day may be far distant when no longer "the horn of the hunter is heard on the hill." If that day ever comes it will mean that sloth has taken the place of energy. If we no longer receive and confer those benefits which are derived from a participation in the mad revelry of the chase, we shall be wanting in part of our national character, and we shall go a long way towards losing that place in the scale of nations which it concerns both our dignity and our interest to occupy.

II.

SEEDS AND FRUITS; THEIR STRUCTURE AND MIGRATIONS.

By A. E. Gibbs, F.L.S.

Read at Watford, 21st January, 1890.

One of the first truths a seeker after knowledge in the kingdoms of nature has to learn is the universal application of the great law of order. Nature allows nothing to happen in a haphazard way, and chance is a word which must not be found in a naturalist's vocabulary. As that quaint old seventeenth-century physician and writer, Sir Thomas Browne, tersely puts it: "All things began in order, so shall they end, and so shall they begin again." All through the realms of nature fixed laws operate, and it is of some of these laws which govern the structure and dissemination of seeds and fruits that I have now to treat.

In the first place we have to ask what is the difference between a seed and a fruit—how may they be distinguished from one another?—for many people seem to regard the two words as synonymous, and use them very loosely. To make the difference clear I may perhaps be pardoned for briefly noticing some very elementary facts in structural botany. Any ordinary perfect flower will be found to be made up of four sets of organs. The first or outer is usually green, and often consists of a number of distinct parts. This is called the calyx, and the separate parts are sepals. Its function is protective—to shield the more delicate inner organs from harm before they arrive at maturity. The second set of organs is generally brightly coloured and is collectively called the corolla, and the separate parts are petals. The function of these coloured leaves is to make the flower attractive. Proceeding still towards the centre of the flower there is next a number of more or less pin-shaped bodies called stamens, in the heads of which a powder called pollen is produced. Then in the very centre are found one or more organs called carpels, constituting the pistil. The function of these last two sets of organs is reproductive, and it is in the carpel that the seeds are formed. A typical pistil consists of three parts—a head or stigma, a column or style, and a hollow part at the base called the ovary, which contains a number of little bodies called ovules. Having proceeded so far it is easy to get at the difference between a seed and a fruit. A seed is simply one of these ripened ovules. A fruit contains the seeds, and consists of the ovary and whatever other parts may persist when the seed is ripe. For instance, an apple is a fruit; its pips are seeds. The fleshy part of the apple is simply the receptacle which was adherent to the ovary and has swollen and become edible.

Having found out the difference between a seed and a fruit, let us now see how a seed grows. That mysterious power implanted within it that we call life of course is beyond our comprehension; all we can do is to watch the process of growth. Three things only are necessary to make a seed germinate—a certain amount of

moisture, heat, and air. It is not absolutely essential that the seed should be planted in the ground. A very old-fashioned experiment will prove that. It is that of the cress seed growing upon a piece of flannel, and here there is certainly no soil present. The seed is merely placed upon a piece of damp flannel, put in a warm place, and it germinates. The young cress plants simply live upon themselves, consuming the food stored up in their own tissues. When that is exhausted the cress dies, for it can get no nutriment from the flannel, and not a sufficient amount from the water to keep it alive. Let the conditions of heat, moisture, and air be applied to a seed—take a pea-seed for instance—and it will begin to swell, and the young plant will burst its envelopes and grow. If we examine the pea-seed carefully we shall find that it really consists of two parts. There is a living part, a small object which is the embryo or young plant, and the remainder consists of the seed coverings, and in some seeds a store of nutrient matter called albumen, on which the young plant is fed until it is able to strike out for itself and get its own living. The seed of the pea contains no albumen, the seed of the wheat on the contrary is made up for the most part of it. The pea starts life on the nutriment contained in the tissues of the seed-leaves.

The laws which regulate the direction of growth are very interesting, but the subject is a complex one.

All good seeds contain an embryo, which as we have seen will become the future plant. This consists of two parts, the radicle from which the young root is developed, and the plumule which becomes the stem. The former invariably grows downwards into the ground, and the latter upwards towards the light, and they do this in obedience to fixed laws. Whichever way a seed may be turned, the direction of growth is always the same. The root obeys a force acting in the same direction as gravitation, that of geotropism as it is called, and therefore commences to descend; but another force also comes into play, called apogeotropism or a growing away from the centre of gravity, both these forces being at work at the same time, one pulling one way and one another.

Darwin, in his most interesting book on 'The Movements of Plants,' has shown that if a number of seeds be thrown on the surface of the ground under conditions suitable to germination, the young root appears and through the combined action of these forces commences to circumnutate, or bow around in a spiral manner. By this means it gradually bends towards the ground, and at length pierces the soil. Then it gives out a number of very fine root-hairs by which it is anchored in position, or the downward thrust of the root would force the young plant out of the ground. The tip of the root goes on growing and circumnutating, and when it comes into contact with any hard substance it bends away from it. So sensitive is it that if it becomes aware of the presence of moisture it will grow towards it. Many experiments were undertaken by Mr. Darwin to show the extreme sensitiveness of the tip of the growing radicle, particulars of which will be found in his book

mentioned above. When the seed germinates in the ground the young stem always grows towards the sun, and this is through the action of another force called heliotropism, or an attraction towards the light. The slightest ray is sufficient to direct it through the smallest fissure. For instance, if a plant be grown in a dark place and a ray of light is thrown down a metal tube, so sensitive is the young stem that it will grow towards that light.

Let us now turn to the consideration of the different kinds of seeds and fruits. A moment's reflection will show how greatly they vary in shape, size, colour, taste, and in many other ways, and we shall see that there are good reasons for all these differences.

Many seeds require protection and are enclosed in a hard covering, and we have a good example of this in the cocoa-nut. There the embryo is almost impregnably fortified by double armour. Not only is there a hard shell, but outside that there is also a thick covering of fibre, from which cocoa-nut matting is made. As the cocoa-nut is often exposed for a great length of time to sea-water, and tossed about by currents and drifted from one island to another, we see how necessary these coatings are for its protection. Many nuts are found strongly protected, especially such as are a favourite food of animals. The poisonous qualities of some fruits have protective functions. Other fruits seem to be protected by the bitter taste of their husks. Many fruits, such as the plum and cherry, which when ripe are edible and luscious, before they come to maturity are sour and unpalatable, but when they begin to approach maturity and the period arrives for the seeds to be set free, a chemical change is set up, the acids disappear, and sugar is formed, making the fruit tempting to the palate of animals. Then in some plants peculiar movements take place in order that the unripe seed may be protected, and we see a very curious example of this in the common dandelion. The flower-head is situated on a long foot-stalk, which, when the flower comes out, stands straight up so that the blossom may be seen by passing insects which perform the necessary offices of fertilization. It remains in that position three or four days. When fertilization has taken place the flower-stalk bends over until the flower-head lies upon the ground and is hidden among the leaves, and there it remains maturing its seed for about twelve days, but as soon as the seed is set the flower-stalk erects itself again that the ripened seed may be carried away by the wind and dispersed. In the cyclamen, after the flower has faded, the stalk curls itself up into a beautiful spiral. The coltsfoot (*Tussilago Farfara*) also inverts its capitulum while the fruit is ripening. Take another instance. The familiar little *Linaria Cymbalaria*, so common on old walls, exhibits a similar set of movements. When the blossom comes out the flower stands up, but after fertilization the foot-stalk bends round and hides among the foliage or in some hole in the wall until the seed is ripe. In plants that grow in the water, the same end is often attained by the flowers rising to the surface for the seed to be set and then sinking into the water again for it to ripen. This is the case with the water-lilies and some

species of *Potamogeton*. These plant-movements, which have for their object the protection of the seed while it is ripening, are very curious and interesting.

The ways adopted by nature to secure dispersal of seeds over the face of the earth will well repay study. The great importance attaching to this subject of seed-transportation will be evident when two things are considered—first, the great advantage to be derived from a rotation of crops; and secondly, and even more important still, the fact that there is going on everywhere a great struggle for existence which necessitates the emigration of seeds, if I may use the term, to places better fitted for their germination. There is a continual fight for life taking place in the plant-world just as there is in the animal kingdom. The individual that is best fitted to its environment survives, the weakest goes to the wall. There is not room for all, *some* must perish. All through the ages this struggle has been raging, each year with greater fierceness as the competition has increased, and the result has been that the strongest has survived. It is a struggle not merely between different species but between individuals of the same species; each seed a tree produces enters into competition with every other seed of the same tree. When we come to consider the high rate of increase that prevails among all organic beings we shall understand how necessary as well as fierce this struggle is. Linnæus has calculated that if an annual plant produces so exceedingly few as two seeds a year, and their seedlings next year produce two, and so on, in twenty years there would be a million of descendants; and if instead of two the seeds yielded were a hundred, or it may be even a thousand, and the plant kept on increasing at the same rate, in the course of a few years there would be no room for any other species to exist.

Mr. George, of Park Street, informed me a few summers since that the produce of one single bean grown in his garden was 132 pods, containing 389 beans. This of course for a bean is a remarkable case, but knock off the odd 89 beans as unripe, or unproductive from any cause, and it will be found that if every one of the 300 beans left went on producing seed in the same ratio, at the end of six years the offspring of that one single bean would be two billions 430 thousand millions of individuals. A bean is a large-seeded plant, and does not yield seed in anything like the number of some smaller plants, so that if numerous enemies were not at work to check this increase the result would be something alarming. With every species increasing at so great a ratio they can only be kept down by this continued struggle which is going on. Species, perhaps at quite different ends of the chain of organic existence, depend upon one another for help, or are kept in check the one by the other as the case may be. Mitigate the agents of destruction, or increase the friendly form ever so little, and a species will almost instantaneously increase by leaps and bounds.

Any number of illustrations of this complex dependence of different species could be given, but take only one. Large tracts

of the Surrey heaths have of late years been enclosed, and wherever this is the case young self-sown fir-trees have sprung up so closely together that there is not room for all to live. On the open heath there is not a single one. Why is it? Simply because by fencing in the land the cattle have been kept from browsing. A search among the heath will reveal the stems of young firs that have been trying to grow and have failed, for as soon as they appeared they were eaten off by cattle. When the cattle are kept away, young fir-plantations spring up all over the place, the seeds being blown from some groups of trees on the neighbouring hills. The face of the country becomes changed from a barren heath to an extensive pine-forest. This instance shows the severity of the struggle going on, and how much influence unlooked-for agents exercise.

The size and number of seeds produced by a plant are also important factors. Minute seeds are more easily carried long distances to spots suitable for germination than larger ones, and so it is often the case that rather large plants produce very tiny seeds, in immense quantities. The contents of the ripe capsule of the orchids resemble snuff, and Darwin has computed that the seeds may number 12,000,000. A single plant of *Sinapis nigra* has been known to yield 8,000 seeds, and a poppy, 60,000.

The means adopted by some plants to disperse their seeds to secure the continuation of the species are very curious. In some cases the seeds are actually thrown considerable distances by the parent plant, as, for instance, in the broom and the little *Cardamine hirsuta*. In the violet family will be found a curious case in point. Of the three commoner species of *Viola* (*hirta*, *odorata*, and *canina*), the dog-violet is by far the tallest and most free-growing plant. In the two shorter species, *hirta* and *odorata*, the fruit, when ripe, simply bends down to the ground and the capsule opens by three valves and allows the seeds to fall out. In the bigger dog-violet a very different action takes place. Here the seed-vessels, though pendant when young, elevate themselves and stand straight up when ripe, as those of the dandelion do, then the seed-vessel opens and the valves contract and curl inwards. Sir John Lubbock found that one gathered plant threw its seeds nearly ten feet. Now we at once ask why the scented and hairy violets do not do the same thing. For this reason. They are short, almost stemless plants, and if they threw out their seeds they would simply strike against some neighbouring herbage and fall to the ground, so that no good end would be served, whereas the dog-violet is a taller plant and so stands above its neighbours and is enabled to throw its seeds over their heads. The wild geraniums also exhibit a curious set of movements for the dispersal of their seeds.

Besides these plant-movements many other agencies are at work to distribute seeds. The wind plays a very important part, and to enable it to act there are many curious adaptations in some plants. In the poppy the fruit opens by pores at the top of the capsule just below the overhanging eaves. When the head is swung by the wind the seeds escape through these little doors.

Then there are many fruits which are provided with a feathery attachment which the wind catches and thus blows them about from place to place, in fact most of the plants which belong to the Compositæ are provided with this hairy structure. In the wild clematis (*C. Vitalba*) the carpels possess a very beautiful feathery down. The Pasque flower (*Anemone pulsatilla*), which may be found growing at Easter time on some of the chalky downs in the north of our county, is of a purple colour, and when it dies off a feathery fruit is developed. The plant is a low one and being hidden in the grass the fruit would stand a poor chance of being blown about by the wind, but between the periods when the flower dies away and the seeds attain maturity the flower-stalk grows, lifting the fruit right away from the involucre of green leaves which enveloped the flower, and so giving it a better chance of catching the passing breeze. Then again in several of our trees the seeds develop a wing-like appendage which bears them up and they are blown long distances.

Many plants develop hooks by which their fruits are carried away in the fur of animals. The involucre of the burdock and the calyx of the forget-me-not furnish familiar examples.

Minute appendages are often possessed by seeds, enabling them to penetrate through grass and other compact herbage, and so reach the soil in which they will often by the same means bury themselves. The tiny barbs with which many fruits are clothed are enabled to propel them forward in the same way as an ear of barley or other aristate grain will, if placed in the sleeve, work its way, by the motion of the arm, to the shoulder. In the Graminaceæ the fruits are for the most part spindle-shaped, and are thus well fitted to penetrate a resisting medium. This is the reason why the floor of a hay-loft is generally covered with seeds which have worked their way through the superincumbent mass of dried herbage. The three most common aids to penetration possessed by fruits are an awn-like appendage, a barbed or scabrid surface, and a fusiform shape.

In a paper recently read before the Natural History Society of Glasgow,* the Rev. A. S. Wilson, B.A., B.Sc., pointed out that the transport of aristate grain may also be indirectly brought about by the action of the wind. Suppose a grain of barley to fall on a waving field of its own species. If the crop is close the seed will float almost as if on water, and, in consequence of its barbed awn, be borne along, worked by waves, as it were, towards the margin or thinner portions of the field. The movements of the barley acting on the barbs of the awn, when it once begins to descend, will cause the seed to force a passage to the soil, into which it may even penetrate some little distance by the same kind of action.

The colouring, too, of fruits is not without significance. A fruit like the cherry or plum, that is green when immature, becomes brightly coloured and attractive when ripe, and so is likely to catch

* "The Dispersion of Seeds and Spores," 'Trans. Nat. Hist. Society of Glasgow,' N.S., vol. iii, p. 83.

the eye of an animal and be devoured. Many seeds contained in esculent fruits have a hard covering and will pass through the stomach of an animal or bird uninjured. It is important and almost necessary that the fruits should be eaten to release the seeds. Very many of our wild shrubs have bright-coloured seeds, as, for instance, the hawthorn, the holly, and the spindle-tree, and it is a general though not invariable rule that gaily-tinted fruits are good for food. The yew furnishes an instance. Every part of the yew is poisonous except the brightly-coloured seed-cup which is a favourite food of birds. These facts furnish examples of the inter-dependence of different divisions of the organic world one upon the other. The tree furnishes food for the bird, and the bird in return distributes the seed for the tree. Sir John Lubbock has prepared an instructive table showing the kind of fruit borne by thirty-three of our common climbing plants, forest trees, and tall shrubs, and it illustrates forcibly the wonderful way in which plants are adapted to circumstances. For instance, out of the thirty-three species enumerated no less than eighteen have edible seeds or fruits, three have fruits provided with feathery hairs, and all the rest have them furnished with wings. The lower shrubs and trees have, in general, the edible fruits, while several of the taller forest trees possess winged seeds or fruit. Not one of these high plants has hooked seeds, for they are above the reach of animals, but in every case the form of fruit is the one best suited for distribution.

Birds are highly effective agents for the transportation of seeds. Although so clean in their habits they will often convey seeds on their bills and in pellets of earth attached to their feet. Mr. Darwin tells us that he had the leg of a red-legged partridge sent to him after it had been kept for three years. There was a large ball of earth adhering to it weighing 6½oz. This was broken, watered, and placed under a bell-glass, when no less than eighty-two plants sprang from it. We can see therefore how easily birds can convey seeds a long distance by this means.

Then again insects act as seed-disseminators. Natal farmers tell us that the great swarms of locusts which visit them bring seeds of injurious plants and introduce them into their grass-land.

Fish, too, may be regarded as plant disseminators, for some species have been known to swallow seeds and subsequently eject them.

One of the most important agents, however, for the distribution of seeds, is water. Tides and currents will convey them from land to land. It may be that a floating nut is simply washed from one island to another, or perhaps, as is often the case, an entire tree is undermined by the waves and floated off to some distant land and there stranded. The roots of the fallen monarch of the forest convey a great deal of earth, and in some coral islands of the Pacific Ocean these stranded trees are eagerly looked for by the natives, who procure the only stones they can obtain for making tools from their roots. These stones are government property and form an important source of revenue. It can hardly fail to happen that some of the seeds attached to the stones and earth will germinate, and so new

species of plants are introduced into the island. Certain kinds of seeds will resist the action of sea-water for a very long period. Mr. Darwin has shown that about ten per cent. of seeds thrown into the sea could be floated by currents across a space of water 900 miles in width and would then germinate. In Holman's 'Travels' an account is given, on the authority of Mr. Keeling, who resided for twelve months on Keeling Island, of the various seeds and other bodies washed ashore there. He shows that a great many seeds are brought from the island of Sumatra and the peninsula of Malacca, and that, from the direction of winds and currents, they could not have come in a straight line, but must have travelled from 1800 to 2400 miles. All the hard seeds, such as those of creepers, retained their germinating power, but the softer kinds were destroyed in the passage.

Rivers, also, play an important part in the transportation of seeds. The huge rafts of matted vegetables and fallen trees which drift down the large rivers of the world often convey seeds many hundreds of miles. The lightness of many kinds of seeds, too, causes them to float for long distances, and after a flood the banks are often strewn with them. There has, for instance, been noticed, growing not far from the mouth of the Columbia river, one or more individuals of *Pinus ponderosa*, a tree which is limited to the north and for some distance to the south of this river, to the dry region east of the Cascade Mountains. There cannot be a doubt that it had been originally brought to the site where it was growing in the form of seeds floated down the river from beyond the Cascades. Many kinds of seeds and fruits are specially adapted for water-transport. The seeds of the water-lily (*Nymphæa alba*) are enclosed in a globular mucilaginous mass of a spongy nature, in which there is a number of air-bells which act as floats. As the mass disintegrates the air-bubbles which have supported it are set free and the seeds escape. These still float until the inflated arillus by which they are surrounded becomes waterlogged, when they sink. By this provision the seeds can be drifted long distances from the parent plant.

I have hitherto been dealing with what may be called the natural means of the dissemination of seeds, but there is another most important agency to be considered. Their designed and accidental transportation by man influences the flora of the different regions of the earth's surface to a degree almost beyond belief. Wherever civilised man takes up his abode there are sure to spring up around him some plants belonging to the country in which he last resided. Many of our familiar plants have taken a firm hold in New Zealand, as, for instance, the watercress, which has been imported and has acquired astonishing vigour, filling the rivers and streams to such an extent as to render navigation difficult. Our little white clover, too, is driving the great New Zealand flax before it. The seeds of these plants were introduced, it may be, by some colonist, for economic purposes, and they have thriven to such an extent as to become a great nuisance. The French gave some New Zealand

settlers the seed of a leek as a special favour, and now it has overrun whole districts, while the common dock is widely disseminated and will remain for ever a proof of the rascality of the Englishman who sold the seeds as those of the tobacco plant.

With every sack of wheat seed that is imported there is sure to be introduced some seeds of plants that grew with it in the harvest-field, and not only do these seeds—which it is difficult to banish from the best cleaned sample—spring up and flourish, but, by a variety of means of which he little dreams, man becomes the agent by which plants are distributed over the earth. They are conveyed by the trader in his merchandise, the sailor in his ballast, the soldier in his accoutrements, and in a hundred other ways. Since the introduction of foreign wools into England many plants from wool-producing countries in distant parts of the globe have sprung up in the vicinity of the places where the wool is washed and bleached. In our own county, at Ware, are extensive brick-fields, and the river Lea is navigable for barges as far as that town. The barges here discharge their loads of ashes and rubbish used in brickmaking, and re-load with bricks. Mr. R. T. Andrews, of Hertford, one day pointed out to me the place where they unload, as a favourite botanical hunting-ground of his, for he had found there a great number of casual plants whose seeds had been brought thus in the barges. In the same neighbourhood, too, there are oil mills, and many strange plants are introduced with the linseed.

A curious case illustrative of the unintentional transportation of plants through human agency is found in the fact that a few years after Thorwaldsen's sculptures had been unpacked in Copenhagen, twenty-five different Italian plants sprang up in the court-yard of the museum, the seeds having been conveyed in the hay and straw which had accompanied the works of art from Rome.

The march of armies can sometimes be traced by the plants which spring up in their track. In 1814 the Russian troops brought, in the stuffing of their saddles, seeds from the Dnieper and the Don to the valley of the Rhone, and even introduced the plants of the steppes into the environs of Paris. A tale is told, for which Sir Bartle Frere is responsible, that the date-palm has sprung up in isolated patches along the line of route taken by the army of Alexander the Great on its return from India, and local tradition ascribes their presence to the stones dropped by the soldiers. However that may be, enough has been said to show what a marvellous power man has exercised in modifying the flora of the earth's surface.

III.

METEOROLOGICAL OBSERVATIONS TAKEN AT THE GRANGE, ST. ALBANS, DURING THE YEAR 1889.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.

Read at Watford, 18th March, 1890.

The meteorological observations, of which the principal results are here given, have been taken in every respect as in the two previous years at St. Albans and the ten years, 1877–86, at Watford.

The accompanying tables (pp. 26, 27) give the monthly means, etc., and the following is the usual summary for the seasons, from December 1888 to November 1889.

Means for the Seasons from Dec. 1888 to Nov. 1889.

Seasons, 1888-89.	Pressure.	Temperature.		Tension of Vapour.	Humidity.	Rainfall.		Cloud, 0–10.
		Mean.	Daily Range.			Total.	Days.	
	ins.	°	°	in.	%	ins.		
Winter	30·044	36·5	10·5	·221	92	4·60	45	7·4
Spring	29·866	46·4	13·8	·266	83	8·82	57	7·3
Summer.....	29·964	59·5	16·3	·405	80	8·97	38	6·5
Autumn.....	30·000	48·6	12·5	·306	90	7·15	41	6·8

The next table gives the difference in each month and in the year between the chief results for 1889 at St. Albans and the means of the same for the ten years 1877–86 at Watford.

Difference in 1889 from Means of 1877-86 at Watford.

Months.	Pressure.	Temperature.		Tension of Vapour.	Humidity.	Rainfall.		Cloud, 0–10.
		Mean.	Daily Range.			Total.	Days.	
	in.	°	°	in.	%	ins.		
January.....	+·177	—1·8	+0·5	—·005	+ 5	—1·44	— 4	+1·1
February	—·031	—4·1	+1·4	—·038	— 2	—0·61	+ 1	—0·5
March	+·026	—1·9	—1·9	—·015	+ 1	+0·18	+ 4	+0·4
April	—·126	—1·7	—2·6	+·009	+12	+0·09	+ 9	+0·9
May	—·120	+3·4	—3·3	+·060	+ 5	+2·10	+ 2	+1·3
June	+·080	+1·3	—0·4	+·029	+ 5	—1·41	— 8	—0·9
July	=	—1·5	—1·9	—·016	+ 2	+2·83	+ 1	+0·7
August	—·040	—1·9	—0·3	+·008	+ 9	—0·46	+ 2	=
September	+·095	—1·0	—1·6	—·007	+ 2	—0·31	— 5	+0·6
October	—·225	—1·0	—1·1	—·001	+ 7	+1·65	+ 9	+0·2
November	+·319	+1·2	—2·6	+·017	+ 3	—1·88	—11	+0·3
December	+·239	—1·0	+0·9	+·001	+ 4	—1·25	+ 2	—0·5
Year	+·033	—0·9	—2·1	+·003	+ 4	—1·51	+ 2	+0·3

Results of Meteorological Observations taken at The Grange, St. Albans, in 1889.

Months.	Pressure of the Atmosphere.	Temperature of the Air.										Humidity of the Air.		
		9 a.m.	Means of		Mean.	Mean Daily Range.	Absolute Min. and Max.				Absolute Range.	Dryness.	Tension of Vapour.	Relative Humidity.
			Min.	Max.			Min.	Date.	Max.	Date.				
	ins.	°	°	°	°	°	°		°		°	°	in.	%
January	30·206	34·0	30·3	40·2	34·8	9·9	17·8	6th	51·7	31st	33·9	0·8	·189	95
February	29·927	34·9	30·3	42·0	35·7	11·7	16·8	13th	56·8	17th	40·0	3·4	·177	87
March	30·002	38·4	33·1	46·0	39·2	12·9	20·1	4th	59·7	24th	39·6	4·5	·195	84
April	29·750	43·8	37·8	51·6	44·4	13·8	32·3	16th	62·5	18th	30·2	3·3	·252	88
May	29·845	56·5	47·6	62·4	55·5	14·8	39·2	2nd	79·1	23rd	39·9	7·3	·351	77
June	30·049	59·1	51·1	68·8	59·8	17·7	44·5	1st	79·2	6th	34·7	7·0	·396	78
July	29·952	59·7	52·1	67·4	59·7	15·3	46·1	19th	78·9	30th	32·8	7·5	·391	76
August	29·891	58·6	51·4	67·4	59·1	16·0	44·0	27th	80·8	1st	36·8	4·0	·427	86
September	30·066	55·4	48·1	62·8	55·4	14·7	36·9	17 & 23	79·0	11th	42·6	4·5	·373	85
October	29·703	46·2	41·6	54·0	47·3	12·4	31·4	13th	59·5	10th	28·2	1·7	·294	94
November	30·231	42·6	38·8	48·2	43·2	9·4	26·0	28th	55·5	15th	29·5	2·2	·251	92
December	30·205	36·1	30·9	41·9	36·3	11·0	19·9	29th	52·0	17th	32·1	1·5	·200	94
Year	29·985	47·1	41·1	54·4	47·5	13·3	16·8	Feb.	80·8	Aug.	64·0	4·0	·291	86

MONTHS.	RAINFALL.					CLOUD.			WIND.									
	Total Fall.	Max. fall in 24 hours.		No. of days of		Mean Amount, 0–10.	No. of days of		Mean Force, 0–12.	Number of days of								
	Ins.	Ins.	Date.	Rain or Snow.	Snow only.		Clear Sky.	Over-cast.		N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
January	1·15	·33	9th	13	3	8·7	3	23	1·7	7	3	0	2	2	5	5	3	4
February	1·98	·46	10th	18	15	7·1	4	14	2·6	5	4	0	0	1	5	9	4	0
March	1·84	·50	17th	16	7	6·7	7	15	2·4	4	3	2	3	4	4	6	5	0
April	2·47	·32	24 & 30	24	0	7·4	2	15	2·1	4	5	4	1	3	6	3	3	1
May	4·51	1·38	26th	17	0	7·7	3	16	1·5	5	3	4	5	6	2	1	1	4
June	1·45	·48	7th	6	0	5·4	11	12	1·4	8	7	2	1	5	3	2	1	1
July	5·36	2·95	12th	16	0	7·2	6	13	2·1	3	6	4	1	3	3	4	5	2
August	2·16	·41	21st	16	0	6·9	3	11	2·1	1	2	0	0	4	11	8	4	1
September	2·30	·73	2nd	8	0	7·0	3	13	2·0	3	7	2	3	1	3	2	9	0
October	3·71	·62	19th	26	0	6·7	9	16	1·6	7	3	0	4	6	4	1	4	2
November	1·14	·45	24th	7	1	6·8	7	15	1·7	1	2	4	4	6	3	2	6	2
December	1·38	·30	21st	19	3	6·8	6	16	1·6	2	4	3	1	6	4	6	2	3
Year	29·45	2·95	July	186	29	7·0	57	179	1·9	50	49	25	25	47	53	49	47	20

The mean temperature of the year was rather low and the mean daily range was small. The rather low minimum of 16°·8 was reached in February, but there was no high maximum. May, June, and November were the only months in which the temperature was above the average, May being very warm. Of the nine cold months February was relatively much the coldest, its mean temperature being scarcely a degree higher than that of January, while it should be 3° higher. The mean pressure of the atmosphere was a little above the average. The lowest pressure recorded at 9 a.m. was 28·985 ins. on 20th March, and the highest was 30·713 ins. on 4th January, giving a range of 1·728 in. The rainfall was a little below the average, but there were two very wet months, May and July. The air was humid almost throughout the year. The sky was rather cloudy.

In the winter of 1888–89 (Dec. to Feb.) the mean pressure of the atmosphere was rather high, the mean temperature was rather low, and the rainfall was very small. In the spring (March to May) mean pressure was rather low, mean temperature a little below the average (the daily range being small), relative humidity great, and rainfall rather heavy (with many wet days). In the summer (June to Aug.) mean temperature was rather low, relative humidity great, and rainfall a little above the average. In the autumn (Sept. to Nov.) mean pressure was rather high, mean temperature a little below the average, relative humidity rather great, and rainfall rather small. Phenomena very near the average are not here mentioned, as usual. The deviations from the means of our period are as follows:—

Difference in 1888–89 from Means of 1877–86 at Watford.

Seasons, 1888–89.	Pressure.	Temperature.		Tension of Vapour.	Humidity.	Rainfall.		Cloud, 0–10.
		Mean.	Daily Range.			Total.	Days.	
	ins.	°	°	in.	%	ins.		
Winter	+·060	−1·4	+0·5	+·018	+ 2	−3·21	− 6	=
Spring	−·073	−0·1	−2·6	+·018	+ 6	+1·37	+15	+0·9
Summer.....	+·013	−0·7	−0·9	+·007	+ 5	+0·96	− 5	−0·1
Autumn.....	+·063	−0·3	−1·4	+·003	+ 4	−1·54	− 7	+0·3

January.—Cold and cloudy, with a very humid atmosphere of high pressure, and a small rainfall with very little snow. The days on which rain fell were 8th to 13th, 19th to 21st, and 28th to 31st, there being thus three dry and three wet periods. Several days between 20th and 28th were foggy. Coldest day 6th, mean 22°·1; warmest day 26th, mean 43°·7. Min. below 32° on 16 days, below 22° on 4 (1st, 2nd, 6th, and 7th); max. above 42° on 12 (below 32° on 4th, 5th, and 6th).

February.—Very cold, of average cloudiness, with a rather dry atmosphere of average pressure, and a rather small amount of rain,

mostly falling in the form of snow. Coldest day 13th, mean 28°·7; warmest day 1st, mean 49°·2. Min. below 32° on 19 days, below 22° on 3 (10th, 12th, and 13th); max. above 42° on 14, above 52° on 4 (1st, 2nd, 17th, and 18th) (below 32° on 11th).

March.—Cold, of average cloudiness, with an atmosphere of average humidity and pressure, and an average rainfall, about half in the form of snow. Coldest days 3rd, mean 27°·8, and 4th, mean 28°·3; warmest days 24th, mean 48°·9, and 25th, mean 48°·8. Min. below 32° on 12 days, below 22° on 2 (3rd and 4th); max. above 52° on 5.

April.—Cold and cloudy, with a very humid atmosphere of low pressure, and an average rainfall but an unusually large number of rainy days, the only days without rain being the 2nd, and 16th to 20th. Coldest day 3rd, mean 36°·2; warmest day 18th, mean 51°·9. Min. below 42° on 25 days (all but 18th to 21st, and 27th); max. above 52° on 13, above 62° on 1 day (18th). There were several thunderstorms.

May.—Very warm, cloudy, with a rather humid atmosphere of low pressure, and a very heavy rainfall, due chiefly to the fall of 1·22 in. on 11th and 1·38 in. on 26th. Coldest day 2nd, mean 47°·6; warmest day 23rd, mean 67°·4 Min. below 42° on 1 day (2nd) (above 52° on 24th and 28th); max. above 62° on 13 days, above 72° on 4 (5th, 22nd, 23rd, and 24th).

June.—Rather warm and bright, with a rather humid atmosphere of considerable pressure, and a very small rainfall. For the first five days and the second half of the month no rain fell. Coldest day 10th, mean 46°·9; warmest day 2nd, mean 68°·1 (temp. at 9 a.m. 71°·6). Min. below 52° on 16 days; max. above 62° on 26 (all but 8th to 11th), above 72° on 10. There was a severe thunderstorm on the 6th.

July.—Cold and cloudy, with a rather humid atmosphere of average pressure, and an excessive rainfall due to the fall of 2·95 ins. on 12th and 1·01 in. on 23rd, leaving only 1·40 in. for the rest of the month. On the 12th nearly all the rain fell during a thunderstorm between 8.45 p.m. and 4 a.m., that is during the night of 12th–13th. Coldest day 24th, mean 54°·5; warmest day 30th, mean 65°·6. Min. below 52° on 14 days; max. above 62° every day but 3 (3rd, 8th, and 23rd), above 72° on 5.

August.—Cold, of average cloudiness, with a very humid atmosphere of rather low pressure, and a rather small rainfall. Coldest days 24th and 25th, mean of each 54°·2; warmest day 1st, mean 68°·5. Min. below 52° on 21 days; max. above 62° on 24, above 72° on 5.

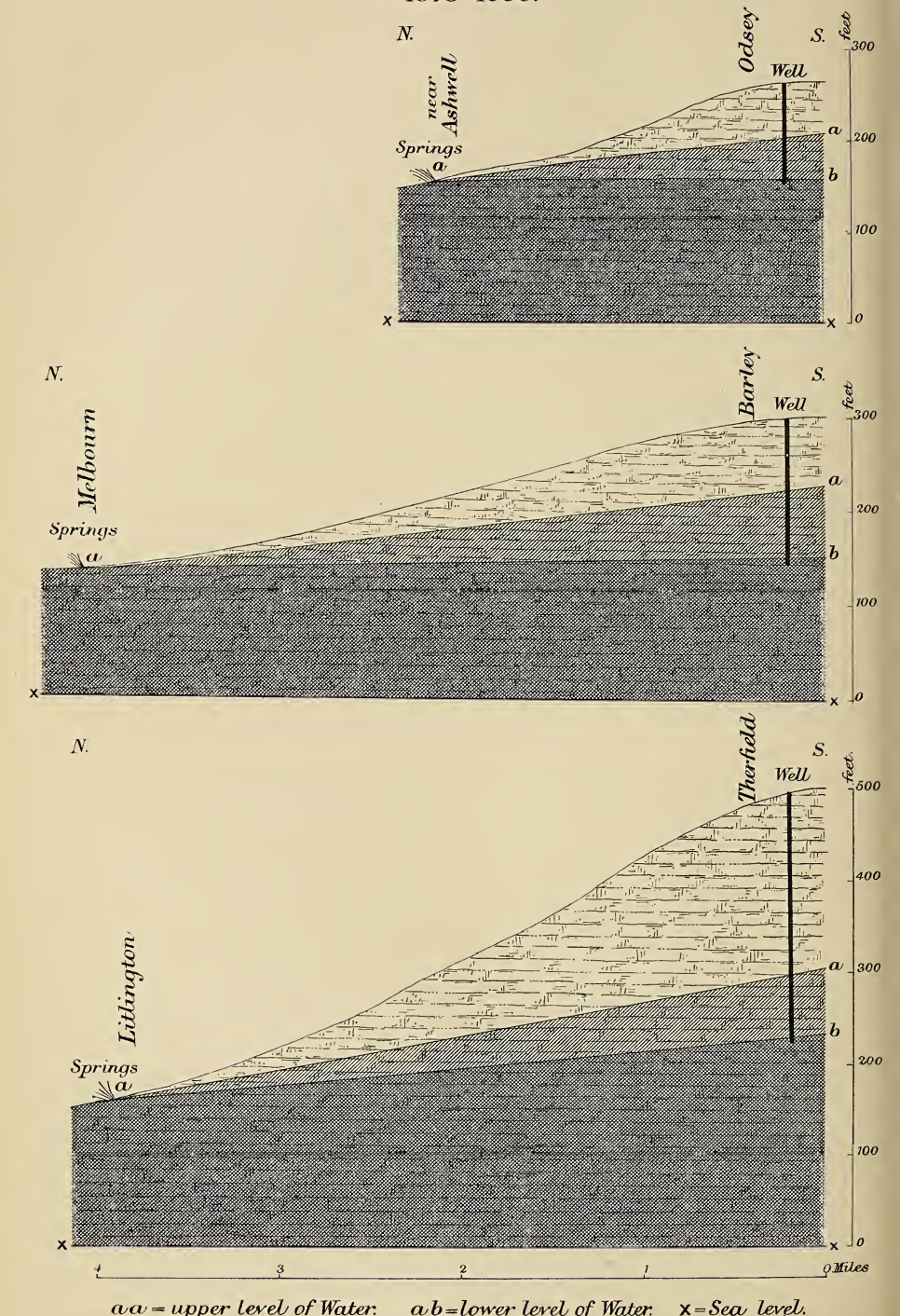
September.—Rather cold and cloudy, with a humid atmosphere of considerable pressure, and about an average rainfall on a small number of days. From 8th to 18th (11 days) no rain fell. The fall on 2nd (1·73 in.) and 24th (0·72 in.) together make more than half the total in the month. Coldest day 25th, mean 44°·9; warmest day 12th, mean 67°·0. Min. below 42° on 7 days (all after 16th); max. above 62° on 15, above 72° on 4 (10th to 13th).

October.—Rather cold, of average cloudiness, with a very humid atmosphere of very low pressure, and a rather heavy rainfall on an unusually large number of days, the only days without rain being 9th, 13th, 14th, 24th, and 29th. Coldest day 13th, mean 42°·8; warmest day 7th, mean 53°·2. Min. below 42° on 15 days, below 32° on 1 (13th); max. above 52° on 22.

November.—Rather cold, of average cloudiness, with a humid atmosphere of very high pressure, and a small rainfall. No rain fell from 4th to 12th (9 days) nor from 14th to 22nd (also 9 days), while only 0·02 in. fell on 13th, this therefore being the only rain in 19 days. Coldest day 28th, mean 29°·8; warmest day 8th, mean 51°·0. Min. below 32° on 5 days (5th, and 26th to 29th); max. above 52° on 7 (all before 16th).

December.—Rather cold and bright, with a rather humid atmosphere of high pressure, and a small rainfall. Coldest day 29th, mean 24°·7; warmest day 17th, mean 48°·3. Min. below 32° on 21 days, below 22° on 2 (29th and 30th) (above 42° on 17th and 18th); max. above 42° on 16 (all between 7th and 26th).

Diagrammatic Sections across the out crop of the Chalk in North Herts, showing relation of underground Water-level to the Wells and Springs. 1878–1888.



a a = upper level of Water. a b = lower level of Water. x = Sea level.

H.G.F. del't.

F.S. Weller, lith.

IV.

A RECORD OF WATER-LEVEL IN A DEEP CHALK WELL AT ODSEY GRANGE, ROYSTON, 1878–1888.

By H. George Fordham, F.G.S.

Read at Watford, 18th March, 1890.

PLATES I and II.

The record of water-level in the well at Odsey Grange, which I commenced in November, 1878, having come to an end on the 1st of October, 1888, in consequence of my residence abroad, I propose to give a résumé of the results of my observations, in order to insure that the labour they have involved may not be entirely lost.

Two years ago, in preparing for our 'Transactions' the observations of the late Mr. John Pearce of Barley,* I expressed the hope that at some future time I might be in a position to deal more in detail than then appeared possible with the interesting question of the underground water-level in the Chalk of North Herts. To do this with any thoroughness a very long series of observations would be necessary. Unfortunately, my own record, upon which I at that time relied prospectively for such a long series, has come to an untimely conclusion, and, in consequence, I merely now record the results such as they are, without attempting any adequate discussion of the subjects upon which they throw light.

I am only aware of three localities within the area formed by the outcrop of the Upper and Middle Chalk in the North of Herts in which observations of the water-level in deep wells have ever been made, namely, Barley,—monthly observations by Mr. Pearce (January 1st, 1864, to October 1st, 1886); Odsey Grange,—daily (November 29th, 1878, to October 1st, 1888); and Therfield Rectory, where a monthly record was commenced by the Rev. J. G. Hale on January 1st, 1883, and, I am happy to say, is being continued at the present time.

These three wells stand upon a line nearly E. and W., a distance of about 2½ miles separating the most westerly well, that at Odsey, from Therfield; Barley being about 4½ miles further E. from the latter village. They are all sunk in the Chalk on its outcrop in the valley of the Cam, along which valley, at lower levels, a number of springs, rising from the outcrop of one of the lower beds of the Chalk (on the horizon of the Totternhoe Limestone), feed the westerly branch of the Cam (or Rhee). (See Plate I.)

The maps illustrating various papers in our 'Transactions,'† as well as those given in the Introduction to the 'Flora of Hertfordshire,' may be referred to for the relative and geological position of these wells.

It will be seen that, while both Barley and Odsey are within the Cam Valley, Therfield stands on the ridge dividing the Cam Valley

* 'Trans. Herts Nat. Hist. Soc.,' Vol. V, p. 20.

† Vol. I, p. 127, and Vol. II, pp. 151, 154.

from the area draining towards the south into the Thames, and upon one of the highest points of that ridge. The surface-flow of water at Therfield Rectory is actually towards the south, while the probable flow of the underground water is to the N.N.W., to the springs in the valley of the Cam.

The nearest of these springs to the three wells respectively, upon a line drawn from each between N. and N.N.W., is, from Odsey, a spring to the E. of Ashwell, distant $1\frac{3}{4}$ miles; from Therfield, one near Litlington (Cambs), distant nearly 4 miles; and from Barley, a spring at Melbourn (Cambs), also about 4 miles from the well. The level of the springs above the sea would be approximately 150 feet: the wells are sunk from a level of 506 feet at Therfield, 305 at Barley, and 265 at Odsey, and their depths are 276, 165, and 104 feet respectively.

With regard to their position geologically, a section given in Mr. Elsden's paper 'On the Post-Tertiary Deposits of Herts'* may be used to assist my explanation. This section is drawn N. and S. across the Cam Valley and the Chalk outcrop. If we consolidate three parallel sections drawn N. and S. through the three wells into one, and place the Therfield well at "Reed Green," to which it is actually very near, Barley will be lower on the outcrop about equidistant between "Reed Green" and "Royston," and Odsey at about the level of "Royston." The line of springs will then be to the N. of "Royston" again. It will be seen at once that the general level of water in the wells on the slopes of the Chalk hills to the southward depends upon the level of this line of springs, a level which is practically uniform and stationary, varying only, at most, to the extent of a few feet between the wettest and the driest seasons. In the Chalk hills to the south of this line of quasi-overflow the variation of level in the underground water becomes greater, the records giving a maximum difference between highest and lowest level of $44\frac{1}{2}$ feet at Odsey, 78 at Barley, and $64\frac{3}{4}$ at Therfield; the greatest difference in any one year (April to March) being respectively $39\frac{1}{2}$ feet (1882–3), 52 feet (1865–6), and 34 feet (1884–5).

The daily record at Odsey is necessarily too voluminous for publication in detail. I therefore content myself with a table of the levels on the first of each month, arranged with the commencement of the year on April 1st, the date at or near which the water-level has attained its maximum elevation as the result of the autumn and winter rainfall, and from which, under normal circumstances, a uniform fall in level continues throughout the summer and autumn.†

To this table is added the mean level for each month for the series of years, and the mean level for each individual year.

For each water-level year is given also the rainfall for the year ending December 31st, so that the rainfall is for a period of twelve months, terminating three months earlier than that taken for the level of the water in the well.

* 'Transactions,' Vol. I, p. 105.

† See the chart of mean monthly level at Barley and Odsey, 'Transactions,' Vol. V, p. 22.

TABLE I.—*Observations of Water-Level in Well at Odsey Grange*, 1878-88, *showing the number of feet of water in the well on the* 1*st of each month, and the Rainfall, in inches, each year to* 1887.

Well situated on the S.E. side of Odsey Grange.
Level of curb 265 feet above Ordnance-datum [nearest B.M. 271·784 feet, about 60 yards distant].
Depth of well from curb. 104 feet; sunk in the Middle Chalk.

	1878–79.	1879–80.	1880–81.	1881–82.	1882–83.	1883–84.	1884–85.	1885–86.	1886–87.	1887–88.	1888.	Mean 1878–88.
April	.....	.....	24½	48	32	42½	24½	12½	30	30½	10½	28¼
May	.....	.....	22½	39	28	35	21½	14	26	26	16½	25½
June	.....	.....	19½	32½	27	31½	18	14½	26	22	19½	23½
July	.....	.....	16½	26½	23	26½	14	15	31	18½	17	21
August	.....	.....	14	21½	19	22½	11½	13	24½	15	13	17
September	.....	41½	12½	17½	15	19	9	9½	19½	11½	10½	16½
October	.....	34½	12	15½	12	16	8	7½	15	9	9	14
November	.....	31	21	14½	10¼	16½	6½	7½	11½	7	.....	14
December	8	27	33	15½	22	18½	5½	.....	11½	6½	.....	16½
January	13	.....	37	29½	32	23½	5½	.....	16½	7½	.....	20½
February	25	21½	40½	35½	39½	25	6½	28	34½	8½	.....	26½
March	41	21	47½	33	50	25½	8½	34	36	8½	.....	30½
Mean level for year	.....	.....	25	27¼	26	25	11½	13	23½	14	.....	.....
Rainfall	1878 22·63	1879 28·24	1880 24·97	1881 21·81	1882 24·14	1883 22·77	1884 16·15	1885 24·79	1886 22·73	1887 15·84	....	....

As the effect of rainfall is in general but slowly operative on deep-seated water-reservoirs, these two distinct periods are convenient for the comparison of the water-level with the depth of surface-fall.

I give also in a separate table the highest and lowest level of water in each year, and the mean highest and lowest, with the date.

The highest level to which the water has attained is therefore 50 feet, on two occasions (March 22nd, 1881, and February 27th, 1883), the lowest to which it has sunk, 5½ feet (December 16th, 1884), giving a maximum difference of 44½ feet. The individual year in which the change of level has been the greatest is 1882–3, from 10 feet to 50 feet, difference 40 feet, a rise extending over exactly four months (October 27th to February 27th). The winter rise of level culminates occasionally in a very rapid upward movement during February, the rise being sometimes as much as 10, 11, 12, or even 13 inches in the 24 hours, for several successive days. In 1879 and 1883 such spurts occurred.

The long summer and autumn fall in level has usually no remarkable features. In June, 1886, however, after an exceptional rainfall in May (4·71 inches), there was a sharp and abnormal rise (May 25th to June 21st) of 8 feet.

In 1879 the water rose all the summer, and reached its highest point in August, in consequence, apparently, of the abnormal summer rainfall (April to September, 20·37 inches). The succeeding autumn being very dry, the water subsequently fell rapidly, and reached a normal autumn level in October, 1880. But, generally speaking, it is the autumn and winter rainfall which goes to supply the underground water reservoirs, and the summer rains, however heavy, affect them but little.

In the accompanying chart (Plate II) I have reduced my observations to the 1st of each month, associating with them the curves for Barley and Therfield so far as they are contemporaneous, and I have added a graphic representation of the depth of rainfall for each month, shown on the 1st of the *succeeding* month. In this chart, which extends from April 1st, 1878, to April 1st, 1889, the vertical scale is 20 feet to 1 inch for the water standing in the wells, (0 being equivalent to the bottom of each well), and one half the actual depth of fall for the rainfall. The vertical lines stand for the 1st of each month, the thicker lines representing the 1st of April in each year.

The relations between the changes of level in the three wells, and between those changes and the rainfall measured on the surface at Odsey, are thus seen at a glance.

In general it will be noticed that the movements of the water are slightly later in time in the deeper wells on the higher ground at Therfield and Barley than at Odsey, while at the same time a close parallelism is maintained in the curves representing the changes of level in the three wells.

The rise from November to March, and the subsequent fall, take place, with more or less modification from the mean curve,

TABLE II.—*Showing the highest and lowest level of Water in Well at Odsey Grange in each year, from Dec.* 1878 *to Oct.* 1888, *and the mean highest and lowest, with date.*

	1878–79 (Imperfect)		1879–80 (Imperfect)		1880–81		1881–82		1882–83		1883–84	
Highest	42½	Mar. 7	42½	Aug. 8	50	Mar. 22	48	Apl. 1	50	Feb. 27	42½	Apl. 4
Lowest	8	Dec. 29	20½	Jan. 17	11½	Sept. 22	14½	Oct. 30	10	Oct. 27	15½	Oct. 9
Difference	34½		22		38½		33½		40		27	

	1884–85		1885–86 (Imperfect)		1886–87		1887–88		1888 (Imperfect)		Mean, 8 years, 1880–81 to 1887–88	
Highest	24½	Apl. 4	34	Mar. 3	37½	Feb. 15	30½	Apl. 4	19½	May 31	39½	Mar. 18
Lowest	5½	Dec. 16	7	Oct. 18	10½	Nov. 19	6½	Nov. 20	9	Oct. 1	10	Nov. 1
Difference	19		27		27		24		10½		29½	

year by year; any abnormal development in the annual curve being generally associated with some exceptional condition relative to the autumn and winter rainfall, and but rarely to that of the spring or summer.

Beyond this it does not appear that any definite deductions can be made.

From a long series of such observations as I have made, and from the comparison of numerous records drawn from different localities, much may in time be learnt of our underground water supplies, and of their connection with our rainfall. For the present I must perforce content myself with this small contribution to the literature of the subject, and to the records of our county.

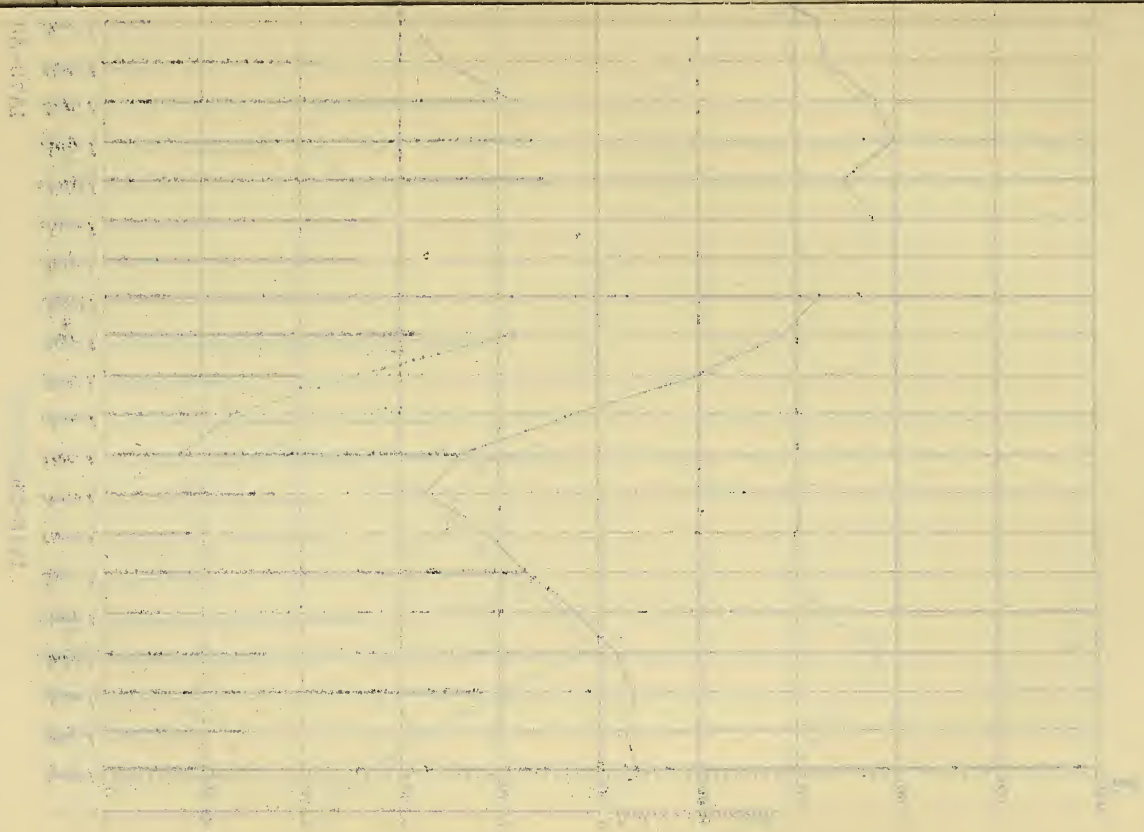
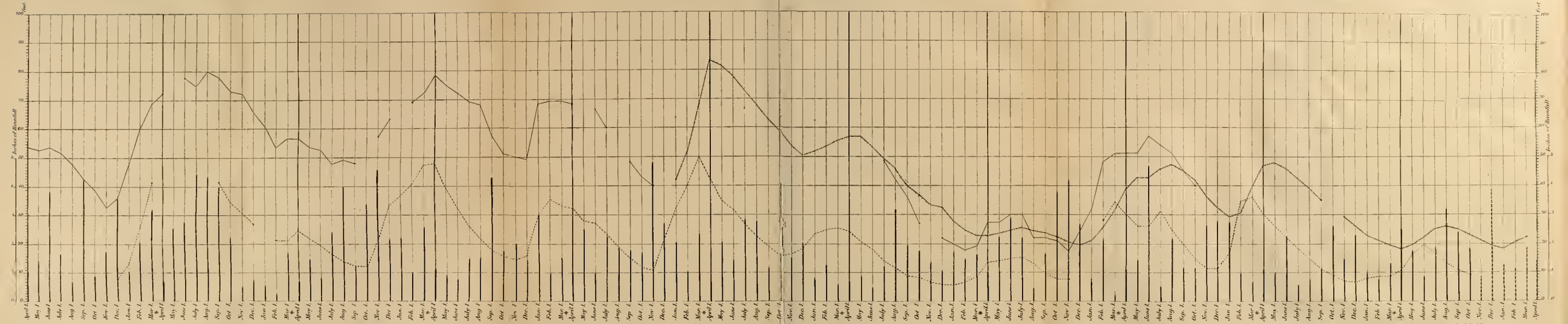


CHART SHOWING WATER-LEVEL IN WELLS AT THERFIELD, BARLEY, AND ODSEY, ON THE 1ST OF EACH MONTH,

(Measured in Feet from the bottom of the Wells,) with the Rainfall of each preceding month.

Depth of wells: Therfield, 276 feet; Barley, 165 feet; Odsey, 104 feet.



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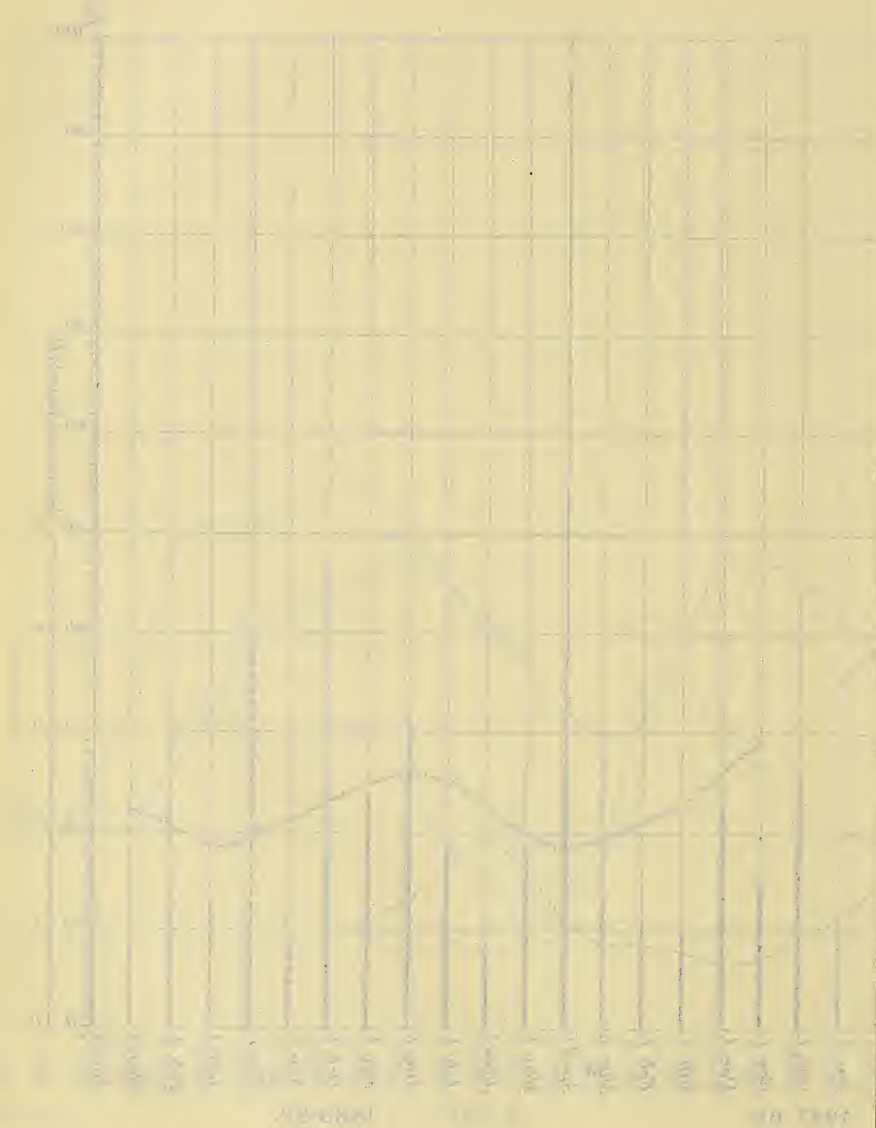
Water-level: Therfield, ——— *Barley,* ——— *(isolated observations,* . . . . *Odsey,* - - - - - - *Rainfall at Odsey,* | *at Therfield,* ¦

F.S. Weller, lith



V.

ON LOCAL SCIENTIFIC INVESTIGATION IN CONNECTION WITH COMMITTEES OF THE BRITISH ASSOCIATION.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.

Read at St. Albans, 16th April, 1890.

I. The British Association and Provincial Societies.

The British Association for the Advancement of Science is in several ways closely connected with many of the provincial scientific societies of Britain. Its annual meetings being held at different places, the societies located in each town in which it meets contribute the principal local scientific element and largely influence their success, while these societies gain by the stimulus which the meetings of the Association give to scientific investigation in their neighbourhood. This mutual benefit is recognised in a rule of the Association which admits, as members of its General Committee, delegates from certain provincial scientific societies. This rule has been revised from time to time. In 1879 and for some time previously it admitted the President of any scientific society publishing Transactions, or *in his absence* a delegate representing him. Therefore if the President of any such society were present at the meeting, for however short a time, there was no option but to appoint him as its delegate.

At the meeting of the Association at Sheffield in that year, with the object of making the rule of more value to the societies represented than it had hitherto been, I suggested to the Council of the Association the admission, as a member of the General Committee, of the Secretary of any duly qualified society as well as the President. The Secretaries having as a rule almost the entire management of these societies, I thought that it might be beneficial to the societies for a Conference of their Secretaries to be held at each annual meeting of the Association, and that, as the names of the "Delegates" are prefixed to the list of members of the Association issued at each meeting, such an alteration in the rule might be the best means of enabling this idea to be carried out.

The suggestion was favourably received by the Council of the Association, a new rule embodying it was passed by the General Committee, and the first Conference of Delegates was held at Swansea in the following year.

The first five annual Conferences were not officially recognised by the Association, and as reports of them were consequently published only in an ephemeral form, I append a brief epitome of the proceedings (Appendix I, p. 45) showing the origin and progress of a movement which has done much to direct the efforts of our provincial societies into useful channels, to bring together in social intercourse their most active members (usually their Secretaries or other officers), and to cement their union with the British Association. With this movement several members of our own Society

have been intimately associated, and the first Committee appointed by the Conference consisted only of two members of our Society. This Committee formed the nucleus of the present Corresponding Societies' Committee.

In the year 1884 the meeting of the British Association was held at Montreal, and there was afterwards held in London an adjourned meeting of the General Committee at which entirely new rules with regard to the representation of provincial societies were passed (Appendix II, p. 48), making the Conferences, from the year 1885, a recognised department of the Association.

The "Conference of Delegates from Provincial Societies" now assembles twice during each annual meeting of the Association, and the "Corresponding Societies' Committee" holds several meetings a year in London. Of this Committee Mr. H. George Fordham was the first Secretary, and he originated and organised most of the work which is now most ably carried on by the present Secretary, Professor Meldola, F.R.S.

At the meetings of the Conference of Delegates the principal subjects discussed are connected with the work of the different committees of the Association appointed to carry on special scientific investigations in which local societies can render aid, members of each committee attending and expressing their requirements to the Delegates who in their turn express their views on the subjects thus brought before them and on other matters of interest to provincial societies; while the work resulting from these meetings is carried on by the Corresponding Societies' Committee.

With regard to the work of this Committee I may mention that its reports, which appear in the annual volumes of the British Association, contain a *résumé* of the proceedings of the Conferences of Delegates, a list of the Corresponding Societies giving particulars as to number of members, entrance fee, annual subscription, etc., and an "Index" to the more important papers published by them each year, especially those giving the results of local scientific investigations. One of the chief objects of the Committee is in fact to further such investigations by giving advice as to subjects for research and methods of conducting it, and by making known, by means of this index, the publication of the results of such research.

Our own Society is one of the Corresponding Societies, and every year but one since its formation in 1875 it has been represented by a Delegate at the meetings of the British Association.*

I will now endeavour to show how we can assist the Committees of the British Association which are at the present time carrying on local scientific investigations, and also how we may help some other societies and individuals engaged in similar work.

* Our Delegates have been as follows:—Dr. John Evans, F.R.S., at Bristol in 1875, Dublin in 1878, Aberdeen in 1885, and Newcastle-upon-Tyne in 1889; Dr. J. Gwyn Jeffreys, F.R.S, at Glasgow in 1876; myself at Sheffield in 1879, Swansea in 1880, York in 1881, Birmingham in 1886, and Bath in 1888; Mr. Fordham at Southampton in 1882, Southport in 1883, and Manchester in 1887; and Professor T. Rupert Jones, F.R.S., at Montreal in 1884. The meeting at which our Society was not represented was that at Plymouth in 1877.

II. Investigation of Subjects of Local Scientific Interest.

The Committees of the British Association doing local scientific work in which we can assist are the following:—In Meteorology that on the Temperature of Surface-water; in Geology those on Underground Waters, Erratic Boulders, and Geological Photography; in Biology those on the Disappearance of Native Plants and on the Cryptogamic Flora and Invertebrate Fauna of our Fresh Waters; and in Archæology that on Pre-historic Remains.

The work of the Boulder Committee has already been brought before our Society by Mr. Fordham,* and he and other of our members have rendered assistance to this Committee by giving accounts of the occurrence, etc., of boulders in the north and centre of Hertfordshire.†

Several of our members are also carrying on investigations as to the circulation of water in the Chalk of Hertfordshire, and we have had from Mr. Fordham two papers on the height of the water in deep wells in the north of the county.‡

We have thus aided two of the three geological committees mentioned, and in view of the recent addition of photography to the subjects of study by our Society, this paper is followed by one showing how we may aid the third geological committee, that on Geological Photography. The work of some of the other committees may possibly be discussed in future papers, but it may be well to partially anticipate these by giving here some information with regard to the investigation of certain subjects of local scientific interest.

A 'Circular referring to Subjects recommended for Investigation by Local Scientific Societies,' drawn up by the Committee of the Conference of Delegates, was issued to the Corresponding and other Societies in 1882. As the Committee then consisted only of Mr. Fordham and myself, no apology I think is needed for making free use of this Circular. In it information was given as to the work of three committees of the British Association, and three subjects investigated by other societies or by individuals. One of these committees, that on Underground Temperature, I am informed by its Secretary, Professor Everett, F.R.S., has almost concluded its labours and no longer requires assistance from provincial societies, and I therefore omit it. On the other hand I have six subjects to add investigated by committees which have been appointed since the Circular was drawn up, and one subject to add to those investigated by other societies. On account of this largely-increased number of subjects to be discussed, I have thought it desirable to give little more than a list of subjects for investigation, and the

* 'Trans. Herts. Nat. Hist. Soc.,' Vol. I, p. 163.

† R. P. Greg, 'Trans. Watford N. H. Soc.,' Vol. I, p. 172; H. G. Fordham, *ib.*, Vol. II, p. 249, and 'Trans. Herts N. H. S.,' Vol. III, p. 33; J. V. Elsden, *ib.*, p. 47. See also H. G. Fordham in 'Rep. Brit. Assoc.' for 1883, p. 143, and R. T. Andrews, *ib.*, 1885, p. 323.

‡ 'Transactions,' Vol. IV, p. 20; Vol. V, p. 31. See also 'Rep. Brit. Assoc.' for 1889, p. 85.

names and addresses of the Secretaries of Committees and others from whom fuller particulars may be obtained.

I have included the Committee on the Rate of Erosion of our Sea-Coast, for, although as an inland Society we can render it no assistance by local investigation, there are several Societies in maritime counties with which we exchange publications, and I hope that this communication may induce others besides the members of our Society to take up the study of some one or more of the subjects mentioned. By so doing they may contribute usefully towards the proceedings of their own local Society, and at the same time promote the general Advancement of Science by the publication of the results of their investigations in the Reports of the British Association.

III. Investigations conducted by Committees of the British Association.

Committees of the British Association are at work upon the following subjects, with respect to which valuable help may be given to them by Provincial Scientific Societies. It will be seen that many observers, spread over the whole country, are required for carrying on the investigations for which the Committees are appointed. Attention is therefore called to the objects which these Committees have in view, and the means by which they hope to attain them; but, as the limits of this schedule do not permit of the insertion of full particulars of the methods of observation employed by the Committees, members of Societies or other observers who may be willing to assist them should communicate with the Secretaries, to whom reports should be sent.

It is recommended that observers who are members of provincial Societies should also communicate to their own Society the information they collect.

1. *Temperature of Surface-Water.*

Committee appointed at Bath, 1888.

Object.—To arrange an investigation of the seasonal variations of Temperature in lakes, rivers, and estuaries in various parts of the United Kingdom in co-operation with the local Societies represented on the Association.

Secretary.—Dr. H. R. Mill, F.R.S.E., Braid Road, Morningside, Edinburgh.

The Committee wishes to ascertain the relation between the climate and weather of different parts of the country and the temperature of the surface-water. This can only be done by the co-operation of a large number of observers with instruments of the same kind and used in the same manner. Thermometers of a special pattern are supplied to observers. The observations should be taken at the same hour every day, if possible at 9 a.m., if not, at 10 or 12.

2. *Underground Waters.*

Committee appointed at Belfast, 1874.

Object.—To investigate the circulation of Underground Waters in the permeable formations of England and Wales, and the quantity and character of the water supplied to various towns and districts from these formations.

Secretary.—Mr. C. E. De Rance, F.G.S., 28, Jermyn Street, London, S.W.

Records of the height of the water in wells, with particulars of the variations of level at different periods, are required, as well as notes on the character of the water, and particulars of the formations from which it is derived.

3. *Erosion of Sea-Coast.*

Committee appointed at Southampton, 1882.

Object.—To investigate the rate of erosion of the Sea-coasts of England and Wales, and the influence of the artificial abstraction of shingle or other material on that action.

Secretary.—Mr. W. Topley, F.R.S., 28, Jermyn Street, London.

It is evidently impossible for any but local observers to record the rate at which erosion is taking place on our sea-coast, for the amount of erosion at any one place varies greatly from year to year. Observers are desired to take measurements periodically from permanently fixed objects, and to record not only the artificial removal of material but also the building of sea-walls, breakwaters, etc., and to look up old plans, deeds, or other documents which may show the position of the sea-coast in former times.

4. *Erratic Boulders.*

Committee appointed at Edinburgh, 1871.

Object.—To record the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England, Wales, and Ireland, to report other matters of interest connected with the same, and to take measures for their preservation.

Secretary.—Rev. Dr. Crosskey, F.G.S., 117, Gough Road, Birmingham.

By the accumulation of information from all parts of the country, and by its careful arrangement and examination, the Committee hopes to arrive at data which will be of material assistance in the study of the history of the Glacial Period.

Boulders are scattered over large districts, particulars concerning them can easily be noted, and as they are continually being destroyed, or removed from their original sites, it is desirable that records should be obtained as early as possible. For this it is evident that a large amount of local assistance is required.

The investigations of this Committee do not extend to Scotland; the Royal Society of Edinburgh having appointed a "Boulder Committee" for that country. Of this Committee Mr. D. Milne Home, M.A., F.R.S.E., 10, York Place, Edinburgh, is the Convener.

5. *Geological Photography.*

Committee appointed at Newcastle-upon-Tyne, 1889.

Object.—The collection, preservation, and systematic registration of Photographs of geological interest in the United Kingdom.

Secretary.—Mr. Osmund W. Jeffs, F.G.S., 12, Queen's Road, Rock Ferry, Cheshire.

A list of the photographs received, with the name of the photographer and of the Society under whose auspices they are taken, will be published annually in the Reports of the British Association.

The size of photograph recommended is "whole-plate" (8½ by 6½ inches), but smaller photographs, if clear, will be received and registered.

6. *Disappearance of Native Plants.*

Committee appointed at Birmingham, 1886.

Object.—The collection of information as to the disappearance of Native Plants from their local habitats.

Secretary.—Prof. W. Hillhouse, M.A., 95, Harborne Road, Edgbaston, Birmingham.

Observations by competent botanists as to the disappearance of native plants and the probable cause are required. The nomenclature adopted in the 8th edition of the 'London Catalogue of British Plants' must be followed, and the numbers prefixed to the names of the species in that catalogue should be quoted. The investigations of this Committee are at present confined to Scotland.

7. *Fresh-water Fauna and Flora.*

Committee appointed at Newcastle-upon-Tyne, 1889.

Object.—To investigate the Invertebrate Fauna and Cryptogamic Flora of the fresh waters of the British Isles.

Secretary.—Prof. J. C. Ewart, M.D., University of Edinburgh.

Observers are desired to note the geological and physical features of the river or lake which they investigate, and the temperature at different periods of the year. This is pre-eminently an investigation for local societies to undertake, for it is one which almost necessitates division of labour, giving work to the members who study meteorology, geology, botany, and zoology, and to specialists in many of the different departments of the last two sciences. Microscopists, especially, may render most valuable aid to this Committee, the invertebrate fauna and cryptogamic flora of our rivers and lakes being chiefly microscopic.

8. *Pre-historic Remains.*

Committee appointed at Birmingham, 1886.

Object.—To ascertain and record the localities in the British Isles in which evidences of the existence of Pre-historic Inhabitants of the country are found.

Secretary.—Mr. J. W. Davis, F.G.S., Chevinedge, Halifax.

The Committee recommends that the pre-historic remains of the British Isles be tabulated under the following groups:—(1) caves and caverns; (2) camps and earthworks; (3) lake-dwellings and crannoges; (4) menhirs and dolmens; and (5) barrows, tumuli, and other burial places. Their position should be laid down on the one-inch Ordnance Survey maps, and distinctive signs should be used, for which see 'Rep. Brit. Assoc.' for 1888, p. 289. The position may be denoted thus:—Aubury Camp, near Redbourn: $46\frac{9{\cdot}6}{3{\cdot}4}$; this indicating that the camp is 9·6 inches from the top and 3·4 inches from the left-hand margin of sheet 46 (old survey), or, on the actual ground, about 9½ miles from the north and 3½ from the west margin of the area represented in the map. (If the maps of the new survey are used, the letters N. S. should precede the number of the sheet.)

IV. Investigations conducted by other Societies or by Individual Observers.

Information with reference to the following subjects is collected by the Societies or observers whose names are given, and further particulars as to the method of observation, etc., will be furnished by them on application. These subjects are all very suitable for investigation by Provincial Scientific Societies.

Observers are recommended, as in the case of subjects investigated by the British Association, to communicate the information they obtain to their own local Society as well as to the Societies or individuals here named.

1. *Rainfall.*

Investigation conducted by Mr. G. J. Symons, F.R.S., 62, Camden Square, London, N.W.

The systematic investigation of the rainfall of the British Isles was commenced by Mr. Symons in the year 1860, and his first report on the rainfall, which was for the years 1860 and 1861, was communicated to the British Association at Cambridge in 1862, a Committee with a grant being subsequently appointed. From 1877 Mr. Symons has undertaken the collection, compilation, and annual publication in his 'British Rainfall,' of statistics of the rainfall of the British Isles at his own expense assisted by contributions from observers and others. His staff of observers now numbers nearly 3000.

Mr. Symons will supply, gratis, Instructions to Rainfall Observers, and forms on which to enter the records to be sent to him. The observations are in all cases to be made daily at 9 a.m., and to be entered to the previous day.

2. *Phenological Phenomena.*

Investigation conducted under the auspices of the Royal Meteorological Society, 30, Great George Street, London, S.W.

A Committee of the British Association was appointed at York in 1844 for the purpose of reporting on the registration of periodical phenomena of animals and vegetables, and in the following year

presented a report which consisted mainly of a series of "Instructions for the Observation of Periodical Natural Phenomena." In 1875 the question was taken up by the Meteorological Society, which then issued a list of plants, insects, and birds recommended to be observed, with a code of instructions to observers. The list was slightly enlarged in 1883, but has now been greatly reduced, and, commencing with the year 1891, records of only twenty-four phenomena, relating to twenty-three species, are required.

Forms on which to record observations, with a list of the species to be observed and instructions to observers, are supplied gratis by the Royal Meteorological Society, and should be returned quarterly to Mr. E. Mawley, F.R.Met.Soc., Berkhamsted, Herts.

3. *Injurious Insects.*

Investigations carried on by Miss E. A. Ormerod, F.R.Met.Soc., Torrington House, St. Albans.

The appearance in unusual numbers of any insects injurious to field- and garden-crops, any injuries done by them, and the degree of success which has attended any methods of prevention which have been tried, should be recorded and communicated to Miss Ormerod, who will assist observers in identifying insects which are injuring crops, and advise them as to the means to be adopted to prevent injury.

Observers are referred for full information, instructions, and illustrations of injurious insects, to the following:—

'A Manual of Injurious Insects,' by Eleanor A. Ormerod. London, 1881. Second edition, greatly enlarged: London, 1890.

'Guide to Methods of Insect Life,' by the same. London, 1884.

From the year 1878 Miss Ormerod has published an annual 'Report of Observations of Injurious Insects.'

4. *Archæological Survey of England.*

Investigations conducted under the direction of the Society of Antiquaries, Burlington House, London, S.W.

The object of the Society of Antiquaries in instituting this investigation is similar to that of the British Association Committee on Pre-historic Remains, but wider in its scope, the Society undertaking the survey of the Roman and Saxon as well as the prehistoric remains (earthworks, etc.) of England. Such remains will be indicated on maps of each county on the scale of eight miles to the inch, each map being accompanied by a classified index. The survey of Kent has already been published, and that of other counties is in progress.

In connection with this subject it may be mentioned that the Anthropological Institute has appointed a Committee to aid explorers of barrows and investigators of other ancient remains by giving advice (by printed instructions, etc.) as to how such work can be performed to the best advantage. Intending explorers are recommended to write to the Secretary, Anthropological Institute, 3, Hanover Square, London, W.

APPENDIX I.

Abridged Report of the Proceedings at the first five Conferences of Delegates from Scientific Societies.

First Conference, Swansea, 31st August, 1880.

John Hopkinson, F.L.S., F.G.S., in the Chair.

An explanation of the object of convening the Conference was given by the Chairman, after which various suggestions were made, principally with the view of securing a better representation of scientific societies at the meetings of the British Association, and a more intimate relationship between provincial societies, and the following resolutions were passed:—

1. "That this Conference recommends that at future meetings of the British Association the delegates from the various scientific societies should meet, with the view of promoting the best interests of the Association and of the several societies represented."

2. "That Mr. John Hopkinson and Mr. H. George Fordham be a Committee to carry out the views expressed at this Conference, and to report to the Conference of Delegates to be held at York in 1881 in accordance with the foregoing resolution."

Second Conference, York, 6th September, 1881.

W. Whitaker, B.A., F.G.S., in the Chair.

The Report of the Committee stated that there had been "issued to all the scientific societies in the United Kingdom entitled to send delegates to the British Association, a report of the Conference at Swansea, and a circular-letter inviting these societies to send delegates to the York meeting;" and also that in order to place the Conferences on a firm basis the Committee had proposed the following resolution which would be brought before the Committee of Recommendations that day:—"That a Committee be appointed, consisting of Sir Walter Elliot, F.R.S., Mr. H. George Fordham, Mr. John Hopkinson, Mr. G. J. Symons, F.R.S., and Mr. W. Whitaker, B.A., to arrange for a Conference of Delegates from scientific societies to be held at the annual meetings of the British Association, with a view to promote the interests of the societies represented by inducing them to undertake definite systematic work on an uniform plan." *

The Report having been adopted, a discussion ensued in the course of which Mr. Hopkinson gave an account of the operations of the Hertfordshire Natural History Society, referring especially to the large number of members who were undertaking the registration of the rainfall; the recording of periodical natural phenomena, such as the time of flowering of plants, the appearance of insects, and the arrival and departure of migratory birds; and also the preparation of lists of the fauna and flora of the county. He felt sure that if the Secretaries of other Natural-History Societies

* This resolution did not then pass the Committee of Recommendations, but its principle was eventually accepted by the appointment of a Committee having a similar object and constitution—the Corresponding Societies' Committee.

would induce the members of their Societies to undertake such work, in which all could take part, not only would science be advanced, but a greatly-increased number of members would take an active and permanent interest in their Society; and to further this end he suggested the preparation and issue, by the Committee of the Conference, of instructions to observers in these and other departments of science.

Mr. Fordham suggested that the local societies might, from their special local knowledge, and from the fact of their being able to obtain the assistance of a great number of observers scattered over large areas of the country, afford help to the Committees appointed by the British Association on such subjects as luminous meteors, the circulation of underground water, erratic blocks, and rainfall.

Mr. Axon said that the Conference would be doing a real service to science if it could induce the local societies to take up such work and also utilise by systematic record the many observations that were being made throughout the country, and which at present were largely wasted.

The former Committee was re-appointed and the following resolutions were passed :—

1. "That the gentlemen named in the resolution appended to the Report take steps to have the Conference of Delegates recognised by the Council of the British Association."

2. "That it be an instruction to the Committee to send out a circular to the various local scientific societies, pointing out the work undertaken by Committees of the British Association, and the valuable aid which may be given by these societies in that and other scientific work."

Third Conference, Southampton, 25th August, 1882.

W. Whitaker, B.A., F.G.S., in the chair.

The Report of the Committee stated: (1) that the Council of the Association had appointed a Committee "to consider the number and position of delegates from scientific societies, and the regulations which should be adopted for governing their relations to the Association;" (2) that "on March 28th Mr. Hopkinson and Mr. Fordham attended [this Committee], when the position and objects of the annual Conference of Delegates were discussed at some length;"* and (3) that "the Committee had prepared and issued the Circular to local scientific societies with a circular-letter drawing attention to the annual Conference, and to the rules of the British Association under which delegates may become members of the General Committee," etc.

The Conference was principally devoted to a discussion on the relation and status of local societies with the British Association.

The Chairman drew attention to the desirability of obtaining greater regularity and method, and a nearer approach to uniformity

* The results of this discussion are embodied in the Report of the Council. 'Rep. Brit. Assoc.' for 1882, p. lviii.

of plan, in the publications of societies having similar objects and undertaking similar work.

Messrs Meldola, Hopkinson, and Fordham were appointed a Committee for making the arrangements for the next Conference, and it was suggested that they should obtain one or two papers on subjects of interest to local scientific societies.

Fourth Conference, Southport, 21st September, 1883.

W. Whitaker, B.A., F.G.S., in the chair.

The Report of the Committee dealt chiefly with the principal subject discussed at the preceding Conference, and stated that the "Local Scientific Societies' Committee" appointed by the Council had presented a preliminary report, which was then discussed by the Conference, its suggestions being generally approved.

A paper on "Local Science Societies and the minor Pre-historic Remains of Britain" was read by Mr. Meldola, in which he urged upon local scientific societies the importance of their undertaking the local care and supervision of pre-historic remains and other ancient monuments, citing the action of the Essex Field Club in the explorations carried on by the Club in Epping Forest.

A paper by Mr. F. E. Sawyer on "The Work of Local Natural History Societies" was also read.

Mr. Fordham read a resolution forwarded for the consideration of the Conference by the Leeds Naturalists' Club, advocating the preparation and annual publication by the Conference of a schedule of subjects of local scientific interest, giving a detailed account of the work which might be undertaken by local societies in co-operation with Committees of the Association.

Fifth Conference, Montreal, 1st September, 1884.

W. Whitaker, B.A., F.G.S., in the chair.

The Report stated that the Council had adopted in substance the recommendations of the Local Scientific Societies' Committee, and that a proposal for the consequent alterations in the rules of the Association would be laid before the General Committee during the present meeting, the effect of which alterations would be that the Conferences would in future be officially convened.

The Chairman introduced the subject of the federation of local societies, referring to the Midland Union of Natural History Societies as a striking illustration of the value of federation.

Professor Trail said that many societies in the neighbourhood of the Tay and Forth, at the suggestion of the Perthshire Society, had amalgamated, and that in north-east Scotland nearly all the Natural History Societies had united, with a successful result.

The Yorkshire Naturalists' Union was also referred to as a federation of societies which worked very well.

The only other subject discussed by the Conference was that of the exchange of publications, which the Chairman stated was of great advantage. A suggestion was made that exchanges might advantageously be conducted through a central depôt in London.

APPENDIX II.

Rules of the British Association with regard to Corresponding Societies and the Conference of Delegates.

Corresponding Societies.

1. Any Society is eligible to be placed on the List of Corresponding Societies of the Association which undertakes local scientific investigations, and publishes notices of the results.

2. Applications to be placed on the List of Corresponding Societies must be addressed to the Secretary on or before the 1st of June preceding the annual meeting at which it is intended they should be considered, and must be accompanied by specimens of the publications of the results of the local scientific investigations recently undertaken by the Society.

3. A Corresponding Societies' Committee shall be annually nominated by the Council and appointed by the General Committee for the purpose of considering these applications, as well as for that of keeping themselves generally informed of the annual work of the Corresponding Societies, and of superintending the preparation of a list of the papers published by them. This Committee shall make an annual report to the General Committee, and shall suggest such additions or changes in the List of Corresponding Societies as they may think desirable.

4. Every Corresponding Society shall return each year, on or before the 1st of June, to the Secretary of the Association, a schedule, properly filled up, which will be issued by the Secretary of the Association, and which will contain a request for such particulars with regard to the Society as may be required for the information of the Corresponding Societies' Committee.

5. There shall be inserted in the Annual Report of the Association a list, in an abbreviated form, of the papers published by the Corresponding Societies during the past twelve months which contain the results of the local scientific work conducted by them; those papers only being included which refer to subjects coming under the cognisance of one or other of the various Sections of the Association.

6. A Corresponding Society shall have the right to nominate any one of its members, who is also a member of the Association, as its Delegate to the annual meeting of the Association, who shall be for the time a member of the General Committee.

Conference of Delegates.

1. The Delegates of the various Corresponding Societies shall constitute a Conference, of which the Chairman, Vice-Chairmen, and Secretaries shall be annually nominated by the Council and appointed by the General Committee, and of which the members of the Corresponding Societies' Committee shall be *ex officio* members.

2. The Conference of Delegates shall be summoned by the Secretaries to hold one or more meetings during each annual meeting of the Association, and shall be empowered to invite any member or associate to take part in the meetings.

3. The Secretaries of each Section shall be instructed to transmit to the Secretaries of the Conference of Delegates copies of any recommendations forwarded by the Presidents of Sections to the Committee of Recommendations bearing upon matters in which the co-operation of Corresponding Societies is desired; and the Secretaries of the Conference of Delegates shall invite the authors of these recommendations to attend the meetings of the Conference and give verbal explanations of their objects and of the precise way in which they would desire to have them carried into effect.

4. It will be the duty of the Delegates to make themselves familiar with the purport of the several recommendations brought before the Conference, in order that they and others who take part in the meetings may be able to bring those recommendations clearly and favourably before their respective Societies. The Conference may also discuss propositions bearing on the promotion of more systematic observation and plans of operation, and of greater uniformity in the mode of publishing results.

VI.

ON GEOLOGICAL PHOTOGRAPHY IN HERTFORDSHIRE.

By John Hopkinson, F.L.S., F.G.S., etc.

Read at St. Albans, 16th April, 1890.

At the meeting of the British Association held at Bath in 1888 Mr. Osmund W. Jeffs read a paper before Section C (Geology) on "Local Geological Photography," in which he suggested the desirability of making a collection of photographs illustrative of the geological features of each county.

The matter was referred, by the Committee of Section C, to the Conference of Delegates, and at the meeting of the Conference on the 18th of September, Professor Lebour, as representative of this Committee, informed the Delegates that it was proposed to appoint a Committee to collect and register local geological photographs, but that the proposal was then so indefinite that it could not be dealt with that year. "It was hoped," he said, "that Delegates of Corresponding Societies, by discussing the matter among themselves, would have it so organised and ready to place before the Committee of the Section next year . . . . that a Committee of the Association might be appointed, with a small grant, to work the scheme satisfactorily." A number of rules, which he read, had been suggested for discussion by the Delegates, but the Committee of the Section did not wish to enforce too many restrictions as to uniformity.

Mr. Jeffs then said that a large number of Societies in different parts of the kingdom had from time to time taken photographs of various geological sections and features as they came under their notice, but there had been no systematic way adopted either of collecting the photographs or of recording them, so that geologists interested might really know what had been taken. He thought that if some arrangement could be made a great deal of good might be done, not only for the benefit of geological science but also for educational purposes.

A discussion ensued, in the course of which it was pointed out that the chief object was to secure photographs of typical and especially of temporary sections.

In the following year, at the Newcastle meeting of the British Association, the subject was again brought before the Conference of Delegates, and Mr. Jeffs stated that he had communicated with the Delegates of the different geological societies in the kingdom, and now had a list of the geological photographs each society had obtained, and a large collection of photographs, which he exhibited.

Subsequently, at the same meeting of the Association, a Committee of seven members was appointed to arrange for the "Collection, Preservation, and Systematic Registration of Photographs of Geological Interest in the United Kingdom." Professor James Geikie, F.R.S., is Chairman of this Committee, and Mr. Osmund W. Jeffs is the Secretary.

Our Society has since received from Mr. Jeffs a circular asking for aid and co-operation in furthering the work of the Committee by supplying him, through its Delegate, with the following information:—

(1) Lists and details of photographs taken, illustrating localities and sections.
(2) Names of local societies, or persons, who may be willing to further the objects of the Committee in their own district.
(3) Particulars of new localities, sections, boulders, or other features which it may be desirable to have photographed.

The circular further states: "The Committee will also be glad to receive a copy of the print from each negative, which will be exhibited at the succeeding meeting of the Association, and afterwards preserved for reference. It is thus hoped to form, eventually, a National Collection of Photographic Views illustrating the Geology of our Country, and deposited in a centre where the collection will be available for purposes of study and comparison. Photographs officially received will be numbered and registered, and a detailed list will be published in the Report of the Committee, showing where the photographs may be obtained."

The Committee has also issued the following

Instructions for the Collection of Geological Photographs.

Photographs are desired illustrative of characteristic rock-sections, especially those of a typical character or temporary nature; railway-cuttings; important boulders; localities [greatly] affected by denudation, or where physiographical changes are in operation; raised beaches; old sea-cliffs; coast-scenery and coast-erosion; characteristic river-valleys, escarpments, and other landscape features; glacial phenomena, such as *roches moutonnées*, moraines, drums and kames, and natural views of geological interest.

I.—The views should be taken under skilled geological direction, and in every case the most typical views should be secured in preference to general views. It may be convenient for Societies to form a small committee for the purpose of noting suitable sections desirable to be photographed, and arranging such work as may be possible in each district. To this end it is anticipated that the services of many amateur photographers may be usefully brought into requisition.

II.—Size of photograph recommended: $8\frac{1}{2}$ by $6\frac{1}{2}$ inches ("whole plate"). (In view of the difficulty of carrying a heavy camera and plates, it is not desired to exclude smaller views when these are well-defined and clear. The size, therefore, is optional.) The views should be printed by a permanent process whenever practicable.

III.—It is necessary, in order to preserve its scientific value, that each photograph should be accompanied by the following details, which may be given on forms supplied as per [reduced] copy on next page, and attached loosely to the photograph (not *fastened* on the back):—

(*a*) Name and position of section or locality.
(*b*) Special feature shown, with illustrative diagrams, when necessary. (Details may be given, if more convenient, on a separate tracing attached to the photograph.)
(*c*) Height and length of section, and compass direction. [The true (*i.e.* not the magnetic) direction should be given.]
(*d*) Name of photographer, and society under whose direction the view is taken.
(*e*) Date when photographed.
(*f*) Indication of direction of light and shade; *i.e.* state whether taken in "direct light" or "in shade."

IV.—Each photograph sent in for registration should bear a *local* number, and the accompanying form should be numbered in accordance therewith. [The space on the right-hand bottom corner is for the use of the Committee.]

V.—Lists of photographs, copies of photographic prints, and information relative thereto, should be sent under cover to the Secretary to the Committee,—Mr. Osmund W. Jeffs, 12, Queen's Road, Rock Ferry, Cheshire,—at the earliest possible date, as the work of registration will be heavy.

FORM A. BRITISH ASSOCIATION COMMITTEE ON GEOLOGICAL PHOTOGRAPHS.			No. of Photo.*
County of	Photographed under the direction of Society.		
Name and position of Locality or Section.			
Special features shown.			
Details of Section.	Height / Length	Compass Direction	"In shade" or "direct light." Time: a.m. p.m.
Sketch, or other particulars, may be given here :—			
Name of Photographer Address	Date photographed		Registered No.

* This Number should also be placed on the back of the Photograph.

It will be seen that one copy of each photograph is required to be sent to the Secretary of the Committee for registration and preservation, and I would suggest that two copies should also be sent to the Curator of our Society for the same purpose, one to be preserved at the head-quarters of the Society, the Watford Public Library, and the other in some public building in the east of the county, such as the Hertford Public Library.

To aid in this work I would ask the assistance of the professional as well as of the amateur photographers in Hertfordshire, whether members of our Society or not.

The question for consideration now is: What is to be photographed? In the "Instructions" of the British Association Committee a general idea is given, and doubtless many examples of geological sections, and of views illustrative of the physical geology of our county, will occur to our geological members. I will instance but a few.

A photograph of the chalk-pit at Boxmoor would show, by the absence of layers of flints and the presence of the Chalk Rock near the top, that it is mainly in the Middle Chalk. Photographs of the chalk-pits by the Colne between Rickmansworth and Harefield,

near the so-called "copper-mills," would not only show them, by the presence of layers of flints, to be in the Upper Chalk, but would also give an instructive lesson in physical geology, for we should find that the chalk where covered by gravel is permeated by "pipes," but that where covered by clay there is not a "pipe" to be seen, the gravel allowing water charged with carbonic acid to percolate through and dissolve the chalk, and the clay forming an impervious capping. This is also well shown in the new cuttings on the extension of the Metropolitan Railway between Rickmansworth and Chorley Wood. A photograph of the chalk-pit on Reed Hill, near Royston, where an anticlinal may be seen in the Chalk, would show that earth-movements of considerable magnitude have occurred since the deposition of the Chalk, and that a range of hills may sometimes coincide with an anticlinal, though here the connection is no doubt accidental.

Very instructive would be photographs of sections of the Woolwich and Reading Beds and London Clay exposed in our brick-fields near Watford and elsewhere, for they would show the variable character of the estuarine and fluviatile Reading Beds, and the persistent character of the marine London Clay. Even many of our gravel-pits might be photographed with advantage to show the varying characteristics of gravels of different ages and situated at different heights.

But the photographs of most general interest would doubtless be those illustrative of the physiographic features of the country; for instance a series showing the Chalk escarpment in its entire range through the north of Hertfordshire and the adjoining counties. Such a series would show the influence upon our scenery of the Totternhoe Stone and the Chalk Rock and of the varying hardness of the different beds of the Chalk, proving the configuration of the country to be almost entirely dependent on the action of sub-aërial denudation on beds which withstand it in varying degrees.

Almost any views taking in a considerable extent of country may indeed be rendered of geological interest by accompanying them with diagrams indicating the formations represented.

Enough has perhaps been said to show that although there is but a small series of rocks present in Hertfordshire, there is sufficient of geological interest to give, with the aid of the photographer, an additional zest to our field meetings, to enrich the collections of our Society with an interesting series of views, and to advance the science of geology, especially in its educational aspects, in which pictorial representation is such a powerful aid.

VII.

SOME HERTFORDSHIRE WELL-SECTIONS. (SECOND PAPER.)

By W. Whitaker, B.A., F.R.S., F.G.S., Assoc. Inst. C.E.

Read at Watford, 22nd April, 1890.

It may be useful to give references to accounts of Hertfordshire well-sections that have been published in Geological Survey Memoirs, or in my earlier paper on the subject communicated to the Hertfordshire Natural History Society in 1885. These are as follows:—

In 'The Geology of London,' etc., vol. ii, pp. 43–58 (1889).—Abbot's Hill, Abbot's Langley (2), Aldenham, Barnet (5), Bayford, Beaumont Green, Boxmoor, Broxbourne (2), Bushey (6), Cheshunt (5), Chorley Wood, Elstree, Essendon (2), Gade Valley (3), Gorhambury, Hatfield (Ponsbourne Park), Hoddesdon (3), Langley (2), Oxhey, Radlett, Rickmansworth (6), Waltham Cross (3), Watford (7), and Wormley (3), or in all 60, of which many had been previously printed in vol. iv of the Memoirs of the Geological Survey (1872), or in 'Trans. Herts Nat. Hist. Soc.,' Vol. III, Part 5, pp. 173–180 (1885).

In 'The Geology of the . . N.E. Part of Herts,' etc. (Sheet 47), pp. 82, 83 (1877).—Amwell (2), Bishop's Stortford (6), Furneaux Pelham, Hadham, Little Munden, Perry Green, Royston (3), and Stocking Pelham, or in all 16.

In vol. iv of the Memoirs of the Geological Survey, pp. 447–454 (1872), the following, which are not included in the London Memoir:—Amwell, Berry Green, Bishop's Stortford (10), Hailey-bury, Hitchin, and Tring, or in all 15.

Of those in my previous paper the following have not been reprinted in the London Memoir:—Albury, Bishop's Stortford, Little Hadham, Much Hadham, Sawbridgeworth (3), and Ware (2), or 9 in all.

There have therefore been published, as above, 100 Hertfordshire well-sections, to which this paper adds 52.

The figures stand for feet, unless otherwise stated.

Amwell.—New River Company. Two wells. Communicated by Mr. J. Taylor, Engineer to the Company, 1885. 1. Amwell Hill (? the same as that noticed in the Memoir on Sheet 47, p. 82). 2. Amwell Marsh. Water-level 29 and 4 feet down respectively.

	1	2
To Chalk	2	5
Chalk	158	377

Aston.—Aston End. Noted by Mr. W. Topley.

Boulder Clay	15	55
Chalk	40	

Aston.—Rectory, 1886. Made and communicated by Messrs. Tilley. Water-level 75 feet down.

		Thickness.	Depth.
[Drift]	Gravel	16	16
	Yellow clay	4	20
	Blue clay	12	32
	Sand and sandstone	45	77
Chalk		30¼	107¼

Berkhamsted.—Waterworks, High Street, next the Town Hall, 1866. 340 feet above Ordnance Datum. Sunk and communicated by Mr. R. B. Paten. Shaft 10 feet, the rest bored. Water stood within 8 feet of the top, the quantity pumped being about 50,000 gallons a day, according to 'A Treatise on Waterworks,' by S. Hughes, p. 218 (1875), whence the figures in brackets are taken.

[Drift]	Clay	6	
	Gravel	4	(6)
Chalk with flints		200	(198)

Berkhamsted.—Messrs. Lock and Smith's Brewery, 1876. Made and communicated by Messrs. Tilley.

		Thickness.	Depth.
Clay and gravel		14	14
[? Upper and Middle Chalk]	Soft chalk	50	64
	Hard chalk	36	100
	Hard chalk, with flints	50	150
	Hard chalk, with water	10	160
	Hard chalk, with flints	40	200
	Limestone	16	216
	Soft chalk	14	230
	Hard chalk	30	260

Bishop's Stortford.—Plaw Hatch, E. of the Town, 1878. Made and communicated by Mr. G. Ingold. Shaft 87 feet (partly old well), the rest bored. Water-level 95 feet down.

		Thickness.	Depth.
[Alluvium] Peat		?	?
Boulder Clay, with a large boulder (2 feet thick) at 47 feet		?	58
[London Clay, 19 feet]	Hard brown clay	2	60
	Dark sandy clay	3	63
	Hard brown clay	14	77
[Reading Beds, 35 feet]	Dark grey sand	2	79
	Dark clay	6	85
	Red sandy loam	2	87
	Red and green loam	6	93
	Green clay	18	111
	Flints	1	112
Chalk, with many flints		100	212

There is some doubt as to the division between the London Clay and the Reading Beds.

Bishop's Stortford.—South Road. Mineral Water Works, 1886. Made and communicated by Mr. G. Ingold. Bored throughout. Water-level 14 inches down.

		Thickness.	Depth.
Made ground		5	5
[Drift]	Gravel	8	13
	Black loam	5	18
	Gravel, with water	15	33
	Grey sand	53	86
[? Drift, or London Clay ?]	Light-brown or grey clays	4	90
	Yellow sandy loam	10	100
	Sand and gravel	5	105
[? Reading Beds]	Sandy loam	2½	107½
	Light-brown clay, with stones	2	109½
	Strong dark-brown clay	3	112½
	Clay, with layers of sand	9	121½
	Gravel [? pebbles]	2	123½
	Sand	9	132½
	Brown clay	2	134½
	Sand	9½	144
Chalk		43½	187½

The depth to the Chalk is greater than in any of the other wells in the town, though the well at the Gas-works approaches this depth, being 135 feet to the Chalk. The thickness of Drift is remarkable, and Mr. Ingold thinks that all the beds above the Chalk may be Drift.

Braughing.—Centre of village. Sunk and communicated by Mr. G. Ingold. Shaft 18 feet, the rest bored.

Gravel and brown clay	8	103
Chalk with flints	95	

Cottered.—Public well, on the Green. Communicated by Mr. A. C. G. Cameron, from information from Mr. Aldridge, well-sinker, Walkern.

		Thickness.	Depth.
[Glacial Drift]	Blue [Boulder] clay and chalk-stones	50	50
	Red loam and flints	10	60
Soft chalk, with 3 feet of stone at the base [? Chalk Rock]		112	172

Cottered.—The Rectory. (Same authority.)

Blue [Boulder] clay and chalk-stones	60	195
Chalk	135	

In October, 1889, the water stood 30 inches in the well, which had not been dry during the last 23 years.

Datchworth.—Welches Farm. Over 1¼ miles S.W. of the church. From Mr. A. C. G. Cameron.

Boulder clay, with flints	15	160
Chalk	145	

Flamstead.—Beechwood. Sunk and communicated by Mr. R. B. Paten. Shaft 80 feet, the rest bored.

Clay and gravel	20	255
Chalk and flints	235	

Furneaux Pelham.—Eastern end, 1884. Made and communicated by Mr. G. Ingold.

		Thickness.	Depth.
[Glacial Drift]	[Boulder Clay] White clay	7	7
	[Boulder Clay] Blue and brown clay	24	31
	Red sand	19	50
	Sand, gravel and loam	27	77
Chalk	....	57½	134½

Gaddesden.—Ashridge Park, 1860. Sunk and communicated by Mr. R. B. Paten. Shaft 225 feet, the rest bored.

Clay and gravel	18	345
Chalk with flints.....	327	

Gaddesden Place, near Water End. For Mr. T. F. Halsey, M.P., 1871. Sunk and communicated by Mr. R. B. Paten. Shaft 200 feet, the rest bored.

Gravel	15	385
Chalk with flints.....	370	

Great Offley.—Wellbury House. Made and communicated by Messrs. C. Isler and Co. Water-level nearly 162 feet down; but no supply of water.

		Thickness. ft.	ins.	Depth. ft.	ins.
Shaft (the rest bored)		—	—	133	6
	Chalk	41	2	174	8
[Melbourn Rock]	Rock	3	0	177	8
[Grey Chalk, 91 feet]	Chalky marl	7	8	185	4
	Hard chalk	5	0	190	4
	Chalky marl	47	3	237	7
	Hard stone	3	10	241	5
	Hard marl	15	2	256	7
	Gault	5	0	261	7
	Very hard marl	2	9	264	4
	Marl	2	10	267	2
	Marl	2	2	269	4
[Totternhoe Stone, 9 feet]	Hard stone	4	4	273	8
	Marl	2	6	276	2
	Hard stone	2	0	278	2
[Chalk Marl]	Marl	16	2	294	4

The divisions of the Chalk have been made by Mr. Jukes-Browne, who also notes that "Mr. R. Street, of Hitchin, says that the original well was sunk in 1822, and that the water-supply, though generally enough in winter and in spring, always partly failed in summer; hence the above boring was made in 1884, but without result. It was stopped by my advice. I recommended that the shaft should be deepened and headings driven. It was found necessary however to sink an entirely new well."

HADHAM, LITTLE.—See LITTLE HADHAM.

HADHAM, MUCH.—See MUCH HADHAM.

HARPENDEN.—Brewery, 1876. Sunk and communicated by Mr. R. B. PATEN. Shaft 58 feet, the rest bored.

Clay and gravel	20	(another account says 5)	
Chalk and flints	180	,,	205
	200		210

HARPENDEN.—Kennesbourn Green. Sunk and communicated by Mr. R. B. PATEN. Shaft 98 feet, the rest bored.

Clay and gravel	30	250
Chalk and flints	220	

HATFIELD.—Astwick Manor (? Astwick Farm, of the old map, 2 miles W.N.W. of the town), 1888. Bored and communicated by Messrs. LEGRAND AND SUTCLIFF. Water-level 25 feet down.

		Thickness.	Depth.
Surface ground		4	4
[Glacial Drift]	Gravel	4	8
	Blue clay and stones	11	19
	Gravel	5	24
	Blue clay	15	39
	Gravel	2	41
	Yellow clay	3	44
	Red sand	5	49
	Gravel and large stones	2	51
Chalk	Chalk marl [soft chalk]	2	53
	Chalk and flints	30	83

HEMEL HEMPSTEAD.—Highfield, N.E. of the Railway Station. Made and communicated by Mr. R. B. PATEN. Shaft 200 feet, the rest bored.

Clay and gravel	45	396
Chalk and flints	351	

HERTFORD.—Fanshaws, Brickendon. For Mr. H. W. Demain Saunders. Made and communicated by Mr. J. A. HUNT, of Hoddesdon. About 310½ feet above Ordnance Datum. Shaft 167 feet, cylinders about 20 feet more, the rest bored. Water-level about 178 feet down.

		Thickness.	Depth.
Drift		6	6
[London Clay, 152 feet]	Blue clay	145	151
	Sandy clay. Shell-bed [basement-bed]	7	158
[Reading Beds, 32 feet]	Grey sands and clay	17	175
	Loamy sands	10	185
	Sand and pebble-bed	5	190
Chalk		129	319

Hertford.—For the Corporation, 1884. Made and communicated by Messrs. Legrand and Sutcliff.

	Thickness.	Depth.
Gravel	16	16
Soft chalk and flints	38	54
Hard chalk and flints	27	81

An older well, for the Waterworks, is 18 feet to the Chalk (Messrs. Docwra).

Hinxworth.—The Schools, N.W. of the Church. Communicated by Mr. A. J. Jukes-Browne. Information from J. Conder, well-sinker, of Baldock. Dug 53 feet, the rest bored.

Gravelly soil	3	183
Blue clay (Gault) to sand	180	

All the wells in Hinxworth and at the coprolite-pits between Hinxworth and Astwick are about the same depth, not varying more than 5 feet, and always finding water in sand below the Gault.

Hitchin.—Highover Farm, N.E. of the town, near the barn. Information given to Mr. Jukes-Browne by the foreman.

Dug through clay and loam	8	16
,, gravel to water	8	

The same water-bearing gravel is intersected in the railway-cutting, into which water often runs. Another well was sunk in a field half a mile due east of the farm, and water found in similar gravel, below clay, about 40 yards from the road leading to Willbury Hill.

Hunsdon Bury.—For Mr. J. H. Buxton, 1882. Made and communicated by Messrs. Docwra. Shaft 56 feet, the rest bored. Water-level 106 feet down.

		Thickness.	Depth.
Undescribed		28½	28½
[Drift]	Blue clay	10½	39
	Sand	9	48
	Gravel	1	49
	Blue clay	7	56
	Sand	15	71
	Gravel	2½	73½
	Loamy sand	1½	75
	Dark sand	4½	79½
Reading Beds.	Coloured [mottled] clay	15½	95
	Sand	1½	96½
	Coloured [mottled] clay	8½	105
	Light[-coloured] sand	10	115
	Green sand	7	122
	Flints.....	½	122½
Chalk		59½	182

LITTLE HADHAM.—Ford near the river. Made and communicated by Mr. G. INGOLD. Bored throughout. Water-level 2 feet down.

Made earth and gravel.....	8	62
Chalk with flints	54	

LONG MARSTON.—Gubblecote, near the stream at the end of the lane a mile E.S.E. of the old church and just outside the boundary of the Upper Greensand, 1885. Trial-boring for water to supply neighbouring villages, made for Mr. A. M. Brown, of Tring, and Mr. A. J. Jukes-Browne, by H. MAYNE. Communicated by Mr. JUKES-BROWNE. 301 feet above Ordnance Datum. Water rose at first (April) to within 60 feet of the surface, and in June it had risen to within 2 feet.

		Thickness.	Depth.
Upper Gault.	Soft blue sandy micaceous marl, yielding a little water	13	13
	Hard bluish sandy micaceous marl, almost a stone, and like Upper Greensand	30	43
	Grey sandy marly clay	26½	69½
	Layer of phosphate-nodules with green sand at the base	0½	70
Lower Gault.	Dark blue clay with ferruginous stains.....	50	120
	Ditto, with lighter-coloured layers of iron-pyrites at 130 and 142	31	151
	Light-grey sandy clay	9	160
	Dark blue clay	11	171
	Light-grey sandy clay, with fragments of shells in the middle part	15	186
	Light-grey clay, with a very hard rocky layer	1½	187½
	Layer of phosphate-nodules	0½	188
	Dark brown clay, with sand and shells, the lower part more sandy and with iron-pyrites	22	210
	Blue clay, with phosphate-nodules at the base	3	213
	Hard light-coloured clay	2	215
Lower Greensand	Hard sandy rock.....	6	221
	Ditto, with quartz pebbles	2	223
	Coarse white sand (chisel dropped)	2½	225½

MUCH HADHAM.—Moor Place, 1887. Shaft throughout. Water-level about 98½ feet down, July, 1877; about 98¾, February, 1888. Communicated by Mr. E. E. BERRY.

		Thickness.	Depth.
Mould	....	2	2
[Glacial Drift]	[Boulder Clay] Brown clay	10	12
	[Boulder Clay] Blue clay.....	17	29
	[Boulder Clay] Brown clay	2¼	31¼
	Gravel and clay, concreted	¾	32
	Grey gravel	4	36
	Grey sand	6	42
	Red gravel	8	50
	Grey gravel, with large stones	2	52
	Yellowish-brown clay	6	58
Chalk	Soft yellow chalk	12	70
	White and yellow chalk, harder	3	73
	Hard white chalk, with flints	44	117

Much Hadham.—Hadham Cross. Coffee Tavern. Made and communicated by Mr. G. Ingold. Bored throughout. Water-level 25 feet down.

Clay and stones	12	80
Chalk with flints	68	

Northchurch (or Wigginton).—Cowroast. For the Grand Junction Canal Company, 1849. Communicated by Mr. S. C. Homersham. 383 feet above Trinity Highwater Mark. Shaft 75 feet, the rest bored. Water-level about 9 feet down.

	Thickness.	Depth.
Gravel	about 8	8
Soft chalk.....	,, 65	73
Hard chalk	,, 32	105

Norton.—Western end of the village. From information given to Mr. A. J. Jukes-Browne by Mr. J. Conder, well-sinker. Sunk 71 feet, bored 30 feet: the greater part through bluish clay with chalk-stones and boulders, with a thin seam of sand yielding a little water near the bottom [? of dug well]; below the sand is more of the like clay, but the boring is chiefly through clunch (Lower Chalk).

Puckeridge.—Mr. G. Covey's. Made and communicated by Messrs. Legrand and Sutcliff.

		Thickness.	Depth.
Dug well (the rest bored)		—	19
[Glacial Drift]	Blue [Boulder] clay	5	24
	Dry gravel	8	32
Chalk		54	86

Puttenham.—In the field formerly worked for coprolites, about three furlongs south of the Church, 1872? Communicated by Mr. A. J. Jukes-Browne, from information got from the well-sinker by Mr. A. M. Brown, of Tring. Sunk 115 feet and bored 110 feet.

Gault clay, with a rock at the bottom.
Sand, without water.
Dark clay, with waterstones.

This boring passed through either Lower Greensand or Portland Sand into the Kimeridge Clay, and no water was found, that necessary for the coprolite-works being obtained from the canal near by. The thickness of the Gault here would be about 150 feet.

Radwell.—Mill. Communicated by Mr. A. J. Jukes-Browne, from information obtained from Mr. J. Conder, well-sinker, of Baldock. Dug 22 feet, the rest bored.

		Thickness.	Depth.
Moory soil		13	13
Chalk Marl.	"Hurrock" or hard clunch.....	50	63
	Coprolites and greensand	1	64
Gault, with a layer of coprolites at the bottom		180	244

The boring was stopped without reaching the Lower Greensand.

Redbourn.—One of 5 borings near the village, for the supply of water to the mills on the river Ver (sunk by Mr. R. Paten), 1851, 1852. Communicated by Mr. S. C. Homersham. The five borings overflowed, yielding 750,000 gallons a day.

	Thickness.	Depth.
Soil and clay	3	3
Gravel	3	6
Chalk, mostly soft, but some hard, with four thick layers of flints	63	69
Chalk, with six beds of "rock" or "rocky chalk"	186	255

Rye Common.—Northern end, a little southward of St. Margarets. For the New River Company, 1885. Made and communicated by Messrs. Docwra. Shaft and cylinders 197 feet 2 inches, the rest bored. Galleries of 69½ and 258 feet at about 142 feet down.

		Thickness.	Depth.
[River Drift]	Loam and stones	3½	3½
	Sandy loam	1	4½
	Loamy clay	1½	6
	Gravel	7¾	13¾
Chalk, 187½ feet.	Chalk and flints	1¼	15
	Soft chalk	? 61	76
	Chalk and flints	? 61	137
	Chalk	64¼	201¼

St. Albans.—Waterworks, close to Bernard's Heath. The smaller and deeper well 1865, the larger 1877. About 410 feet above Ordnance Datum. Communicated by the Engineer, Mr. A. F. Phillips. Shafts 200 and 180 feet, connected by a tunnel, and with headings also. Boring, in deeper shaft, to 66 feet. 30,000 gallons an hour have been pumped and more might be.

Gravel	30	266
Chalk; some very hard about 100 feet down [? Chalk Rock]	236	

A communication from Mr. R. B. Paten, referring to extensions of the newer well in 1882 (shaft deepened 5 feet, headings driven out, and borings of 140 feet), gives the following section:—

Clay and gravel	60	325
Chalk and flints	265	

The new works, at the foot of Holywell Hill, have been described in 'Trans. Herts Nat. Hist. Soc.,' Vol. IV, Part 4, p. 117, and are only about 250 feet above Ordnance Datum. A section of the well, communicated by Messrs. Legrand and Sutcliff, is as follows:

	Thickness.	Depth.
Dug well	—	4
Gravel	20	24
Chalk and flints	126	150

St. Albans—Hawkswick, north of the town and west of the Harpenden Road. Made and communicated by Mr. R. B. Paten. Shaft 148 feet, the rest bored.

		Thickness.	Depth.
[Brick-earth and Clay-with-flints ?]	Clay and gravel	35	35
	Rock [flints ?]	6	41
Chalk and flints		274	315

St. Albans.—New House Farm, a little south of the above. Information from the occupier, to Mr. A. C. G. Cameron.

		Thickness.	Depth.
Sand and gravel		10	10
Chalk	Chalk with flints	120	130
	Stone, from which the water is said to come [Chalk Rock?]	5	135

St. Margarets.—Hailey Hall, 1887. Made and communicated by Messrs. Legrand and Sutcliff. Water-level 67 feet down, in August, 1887.

		Thickness.	Depth.
Pit		—	$9\frac{3}{4}$
[? Drift or Eocene]	Clay	7	$16\frac{3}{4}$
	Sand and gravel	28	$44\frac{3}{4}$
Chalk and flints		55	$99\frac{3}{4}$

Sawbridgeworth.—Spillbrook Lane, 1889. Made and communicated by Mr. G. Ingold. Water at 23 feet.

		Thickness.	Depth.
Made ground		1	1
[Drift]	Brown clay	10	11
	Gravel.....	1	12
[? London Clay]	Yellow loam	3	15
	Black sandy loam	8	23
	Brown clay	11	34
	Dark brown clay	7	41

A well at Allen's Green, to the N.W., is 25 feet deep, in white and blue Boulder Clay (same authority).

Shenley.—Porters. Communicated by Messrs. Legrand and Sutcliff. Water-level $19\frac{1}{4}$ feet down.

Dug well (the rest bored) [London Clay and Reading Beds?]	200	}	$237\frac{1}{2}$
Chalk and flints	$73\frac{1}{2}$	}	

Shephall.—Shephall Bury, 1885. Made and communicated by Messrs. Tilley.

		Thickness.	Depth.
[Drift]	Old well	—	80
	Sand	4	84
Chalk		36	120

Thorley (near Bishop Stortford).—Whitelands, 1888. Bored and communicated by Messrs. Legrand and Sutcliff. About 285 feet above Ordnance Datum. Water-level 112 feet down.

		Thickness.	Depth.
Dug well [? Boulder Clay]		—	20
[Glacial Drift]	Boulder clay	42	62
	Loamy clay and water	4	66
	Boulder clay	3	69
	Ballast [gravel]	10	79

THORLEY *continued*:—

		Thickness.	Depth.
[London Clay? and Reading Beds]	Clay	2	81
	Sand	11	92
	Mottled clay and sand	8	100
	Blue loamy sand	10	110
	Mottled clay and sand	13½	123½
	Pebbles and flints	2½	126
Chalk.	Chalk and flints	5	131
	Discoloured chalk	16	147
	White chalk and flints	53	200

WALKERN.—Information got by Mr. A. C. G. CAMERON.

Boxhall Farm, a mile west of the village.

[Boulder] clay	30	} 190	
Chalk	160		

Clay End Cottage, a mile south-east of the village.

[Boulder clay]. Blue clay and chalk-stones	80	} 100	
Chalk	20		

Victoria Brewery.—From notes by Mr. HOLLAND, manager, 1876. Old shaft 100 feet, the rest bored. Water stands 12 feet down, and the yield is 12 barrels an hour (1889).

Soil			
[Boulder Clay]. Blue clay and chalk-stones, with gravelly seams	200	} 300	
Soft chalk, with a very hard bed at the top	100		

The last two sections seem to point to the occurrence of a deep mass of Drift in the Chalk valley, perhaps a channel of a like kind to that in a neighbouring part of Essex (Cam Valley) described in 'Quart. Journ. Geol. Soc.,' vol. xlvi, pp. 333-340 (1890).

WALTHAM CROSS.—Gasworks, 1880. Made and communicated by Messrs. TILLEY.

		Thickness.	Depth.
[River Drift].	Gravel	12	12
Blue [London] clay	....	43	55
[Reading Beds]	Mottled clay	13	68
	Sand and pebbles	57	125
Chalk and flints	....	85	210

WARE.—Mr. Clark's. Made and communicated by Messrs. LEGRAND AND SUTCLIFF. Water-level 74½ feet down.

		Thickness.	Depth.
Dug well (the rest bored)		—	4
[Drift]	Clay and stone	13	17
	Flints	¾	17¾
	Clay and flints	2	19¾
	Clay mixture	9¾	29½
	Clay	7	36½
	Clay and pebbles	8½	45
	Gravel	13	58
Chalk	....	54	112

Ware.—Waterworks. North-east of the Union, 1870. Communicated by Messrs. Russ and Minns, Engineers. 215 feet above Ordnance Datum. Shaft, with two headings. Water-level about 100 feet down. Yield about 140 gallons a minute.

Gravel, etc., about	30	} 120
Chalk ,, ...	90	

Watton.—Blue Hill, a mile north-west of the Church. Information got by Mr. A. C. G. Cameron from Mr. Aldridge, well-sinker.

		Thickness.	Depth.
Glacial Drift.	(Boulder Clay). Blue clay with chalk-stones	40	40
	Coarse gravel	7	47
	Concrete (cemented Drift), to get through which took seven days	4	51
	Gravel and a deposit like wood-ashes	15	66

The writer will be glad to receive notes of corrections or of additions to published well-sections, as well as accounts of new wells.

VIII.

REPORT ON THE RAINFALL IN HERTFORDSHIRE IN 1889.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.

Read at Watford, 22nd April, 1890.

There are a few alterations in the staff of our observers of the rainfall, resulting in an increase, for the year 1889, of two rainfall stations. The return for Watford House could not be accepted, owing to omissions in it; but, as Mr. Forrester Scott has favoured me with a return for Bushey Heath, the number of our stations in the Lower Colne district remains the same as before. In the report for the previous year it was stated that we had only one observer in the large district of the Beane; we have now two, Mr. Marlborough Pryor having communicated his return for Weston Manor, Stevenage. The other addition is that of a former station, Brocket Hall, Hatfield, for which a return has been received from Mr. J. Landon, increasing the number of our stations in the Upper Lea District to four.

The present report is thus drawn up from returns for 30 stations, and from 23 of these I have the daily rainfall. I have not included in the principal table the records of the second and third gauges at Rothamsted, the 8-inch and the one-thousandth-of-an-acre gauge,* this table therefore comprising the records of the same number of gauges as before.

Particulars of the rainfall stations, and the monthly and total rainfall and number of days on which 0·01 in. or more fell, are given in the accompanying tables (Tables I and II, pp. 66, 67).

The mean rainfall in the county in the year 1889 was 27·50 inches. This is 1·50 in. below the mean of the 10 years 1876–85, and 1·15 in. above the mean of the 40 years 1840–79. While thus about a fair average amount, there were heavy falls on the 11th and 26th of May; and on the 12th of July there was an unprecedentedly heavy fall over nearly the whole of the county, most of the observers recording it as the greatest they have ever measured. Of this fall I have elsewhere given an account.†

Distribution of Rainfall throughout the Year.—Of the total rainfall 16°/₀ fell during the winter months (Jan., Feb., and Dec.), 30°/₀ during the spring (March to May), 30°/₀ during the summer (June to Aug.), and 24°/₀ during the autumn (Sept. to Nov.). The fall of each quarter and of each season, and their deviation from the mean of our period (1876–85), was as follows:—

	Fall.	Diff.		Fall.	Diff.
1st quarter.....	4·86 in.	—1·15 in.	Winter.....	4·39 in.	—2·76 in.
2nd ,, ...	8·21	+1·57	Spring.....	8·19	+2·45
3rd ,, ...	8·42	+0·22	Summer	8·26	+0·54
4th ,, ...	6·01	—2·14	Autumn	6·66	—1·73

* These were respectively 29·13 ins. on 164 days, and 30·56 ins. on 176 days.

† 'Hertfordshire Constitutional Magazine,' vol. iii, pp. 6–8 (Sept. 1889).

Table I.—Hertfordshire Rainfall Stations.

River District.	Station.	Observer.	Latitude.	Longitude.	Diameter of Gauge.	Height of Gauge above Ground.	Height of Gauge above Sea-level.
			° ′ ″	° ′ ″	ins.	ft. ins.	ft.*
Ouse / Thames / Thame / Ivel / Cam / Rhee	Royston	Hale Wortham	52 2 34 N	0 1 8 W	8	0 6	269
Hiz	Hitchin	William Lucas	51 57 0 N	0 16 20 W	5	2 1	238
Hiz	,, High Down	Joseph Pollard	51 57 40 N	0 20 0 W	5	1 1	422
Up. Thame	Tring Vicarage	Rev. W. Quennell	51 47 33 N	0 39 25 W	5	1 0	442
Bulbourne	Cowroast	Hubert Thomas, C.E.	51 47 0 N	0 36 30 W	10	4 2	345
Bulbourne	Berkhamsted—Rosebank	Edward Mawley	51 45 40 N	0 33 30 W	8	1 0	401
Gade	Great Gaddesden Vicarage	Rev. W. T. Drake	51 47 20 N	0 30 30 W	8	1 0	426
Gade	Hemel Hempsted—Nash Mills	J. Dickinson & Co.	51 44 0 N	0 26 40 W	12	3 9	237
Ver	Kensworth—The Grove	Miss S. Grace Jones	51 51 30 N	0 30 0 W	5	1 0	630
Ver	Harpenden—Rothamsted	Lawes and Gilbert	51 48 10 N	0 21 30 W	5	0 9	420
Ver	St. Albans—The Grange	John Hopkinson	51 45 9 N	0 20 6 W	5	1 0	380
Ver	,, Gorhambury	Rt. Hon. Earl of Verulam	51 45 20 N	0 23 0 W	6 sqr.	2 6	413
Lo. Colne	Watford—Oaklands	Edward Harrison	51 40 5 N	0 24 20 W	5	5 6	273
Lo. Colne	,, Bushey Heath	Forrester Scott	51 38 0 N	0 20 0 W	5	1 0	480
Mimram	Rickmansworth—Moor Park	Rt. Hon. Lord Ebury	51 37 30 N	0 26 20 W	5	2 0	340
Mimram	Welwyn Rectory	Rev. Canon Wingfield	51 49 50 N	0 12 30 W	5	0 6	228
Beane	Datchworth Rectory	Rev. J. Wardale	52 2 0 N	0 10 0 W	5	1 0	386
Beane	Stevenage—Weston Manor	M. R. Pryor	51 57 20 N	0 9 30 W	5	0 9	500 ?
Rib	Bennington Lodge	Rev. J. D. Parker, LL.D.	51 53 45 N	0 5 20 W	5	1 0	408
Rib	Therfield Rectory	Rev. J. G. Hale	52 1 0 N	0 3 0 W	5	4 3	500
Ash	Throcking Rectory	Rev. C. W. Harvey	51 57 5 N	0 3 0 W	5	1 0	484
Ash	Much Hadham	T. Woodham Mott	51 51 24 N	0 4 38 E	5	1 0	222
Upper Lea	Hatfield—Brocket Hall	J. Landon	51 48 0 N	0 14 0 W	8	1 0	250 ?
Upper Lea	Hertford—Bayfordbury	W. Clinton Baker	51 46 30 N	0 5 30 W	8	1 2	250
Upper Lea	Ware—Red House	Joseph Francis, C.E.	51 46 0 N	0 6 0 W	12	3 0	114
Upper Lea	,, Fanhams Hall	Miss Joyce Croft	51 49 30 N	0 1 30 W	8	1 0	253
Lower Lea	Broxbourne	G. J. Newbery	51 44 30 N	0 1 0 W	5	1 0	118
Lower Lea	Cheshunt College	Rev. Dr. Reynolds	51 42 5 N	0 2 50 W	5	1 1	94
Lower Lea	New Barnet—Gas Works	T. H. Martin, C.E.	51 39 5 N	0 10 15 W	8	0 9	212
Lower Lea	Southgate—The Lawns	George A. Church	51 37 40 N	0 8 0 W	5	0 6	240

* For explanation of these symbols see p. 84.

TABLE II.—RAINFALL IN HERTFORDSHIRE IN 1889.

STATIONS.	JAN.	FEB.	MAR.	APL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR.	DAYS.
*Royston	·95	1·80	1·23	2·44	3·46	2·47	2·89	1·54	2·05	3·80	·79	·99	24·41	158
Hitchin	·92	1·63	1·40	2·30	4·33	1·72	4·30	1·21	1·69	3·41	·97	·85	24·73	176
* „ High Down	1·05	1·50	1·40	2·22	5·00	1·46	6·34	1·52	2·00	3·70	·96	·83	27·98	160
*Tring Vicarage	1·38	2·40	2·37	2·96	4·21	1·17	4·49	2·41	1·61	3·87	1·21	1·15	29·23	180
*Cowroast	1·42	2·35	2·27	2·78	4·04	·90	[4·38]	2·29	1·67	4·00	1·35	1·49	[28·94]	
*Berkhamsted—Rosebank	1·39	2·55	2·13	2·94	3·78	·67	3·34	2·28	1·60	3·57	1·39	1·23	26·87	190
*Great Gaddesden Vicarage	1·45	2·20	1·91	3·51	3·62	·88	3·63	2·71	1·48	3·32	1·23	1·34	27·28	178
*Hml. Hempsted—Nash Mills	1·25	2·03	1·82	2·54	3·28	1·07	5·60	2·74	1·38	2·94	1·55	1·42	27·62	151
*Kensworth	1·62	1·98	2·12	2·82	4·37	·74	6·86	2·64	1·12	4·16	·58	1·75	30·76	152
*Harpenden—Rothamsted	1·19	1·80	1·80	2·39	4·90	1·21	5·59	2·08	2·36	3·57	1·14	1·39	29·42	168
*St. Albans—The Grange	1·15	1·98	1·84	2·47	4·51	1·45	5·36	2·16	2·30	3·71	1·14	1·38	29·45	186
„ Gorhambury	1·03	1·61	1·84	2·25	4·59	1·04	4·28	2·38	1·82	3·38	1·24	1·25	26·71	
*Watford—Oaklands	1·30	2·01	2·08	2·55	4·24	1·52	2·79	2·43	1·85	3·03	1·42	1·54	26·76	182
„ Bushey Heath	1·13	2·38	2·20	2·36	4·21	1·45	3·15	2·89	2·27	3·68	1·20	1·57	28·49	168
*Rickmansworth—Moor Park	1·30	2·84	2·30	2·80	3·99	1·19	2·03	2·70	2·36	3·72	1·84	1·95	29·02	184
*Welwyn Rectory	1·01	2·04	1·60	2·48	4·11	2·19	[5·64]	2·10	1·20	3·61	·88	1·13	[27·99]	163
*Datchworth Rectory	·98	1·56	1·32	2·12	3·79	1·75	4·94	1·84	2·25	3·15	·86	1·07	25·63	162
Stevenage—Weston Manor	1·02	1·65	1·77	2 64	4·64	2·09	3·68	1·24	1·57	3·78	1·16	1·15	26·39	173
*Bennington Lodge	1·10	1·98	1·43	2·89	4·22	2·09	4·93	2·00	2·13	3·99	1·02	1·37	29·15	210
*Therfield Rectory	1·09	1·81	1·40	2·93	3·94	1·75	3·42	1·89	2·17	4·18	1·01	1·21	26·80	169
*Throcking Rectory	·85	1·86	1·59	1·91	3·31	2·06	4·50	1·73	2·13	3 61	·97	1·05	25·57	165
*Much Hadham	·82	2·02	1·73	2·26	3·28	2·65	4·17	2·32	2·00	3·46	·98	1·48	27·17	164
Hatfield—Brocket Hall	·97	1·84	1·76	2·21	4·05	2·44	5·07	1·81	1·78	4·09	1·13	1·10	28·25	138
Hertford—Bayfordbury	·90	1·84	1·64	1·58	3·34	3·22	4·90	1·70	2·37	3·81	·93	1·80	28·03	167
*Ware—Red House	·78	1·63	1·62	2·05	3·82	2·00	5·35	1·77	2·16	3·06	1·00	1·14	26·38	169
* „ Fanhams Hall	·83	2·22	1·76	2·17	3·48	2·30	5·19	1·94	1·99	3·39	·73	1·26	27·26	187
*Broxbourne	·84	2·36	1·88	2·25	3·82	2·16	3·78	2·32	2·72	3·77	1·12	1·26	28·28	192
Cheshunt College	·75	2·02	1·70	2·05	4·40	2·11	3·23	2·98	2·88	3·36	1·01	1·19	27·68	142
*New Barnet—Gas Works	·87	1·95	1·68	1·37	3·81	2·84	2·70	2·99	1·42	3·71	·93	1·29	25·56	145
*Southgate—The Lawns	1·33	2·23	1·57	2·03	3·80	2·89	2·46	2·88	2·21	3·77	1·02	1·28	27·47	173
Mean for the County	1·09	2·00	1·77	2·41	4·01	1·79	4·29	2·18	1·95	3·62	1·09	1·30	27·50	170

* Daily fall received from the observers at these stations.

January and November were the driest months, May and July the wettest; October also was a wet month. The difference in each month from the mean of our period was:

	in.		in.		in.		in.
Jan.	—0·94	April	+0·15	July	+1·76	Oct.	+0·84
Feb.	—0·45	May	+2·06	Aug.	—0·58	Nov.	—1·61
Mar.	+0·24	June	—0·64	Sept.	—0·96	Dec.	—1·37

The fall was thus below the mean in the beginning and end of the year and above it in the middle, the greatest defect being in the winter and the greatest excess in the spring.

The absolute maximum fall in any one day in each month and the station recording it was:

	ins.		ins.
Jan. 9—Cowroast, Tring	0·60	July 12—High Down, Hitchin	3·76
Feb. 10—Broxbourne	0·75	Aug. 21—Bushey Heath	0·97
March 7—Kensworth	0·75	Sept. 24—Moor Park	1·34
April 24—Therfield	0·63	Oct. 21—Therfield	1·36
May 26—Gorhambury	2·25	Nov. 3—Moor Park	0·71
June 7—Bayfordbury	1·85	Dec. 21— ,,	0·57

The wettest day in each month at the 30 stations was:

January 8th at 1; 9th at 28; 13th at 1.

February 3rd at 1; 6th at 7; 10th at 17; 11th at 2; 13th at 1; 18th at 1; 6th and 10th equal at 1.

March 6th at 1; 7th at 16; 8th at 5; 19th at 1; 20th at 6; 21st at 1.

April 3rd at 2; 4th at 2; 9th at 1; 10th at 8; 23rd at 1; 24th at 11; 30th at 1; 9th and 24th equal at 1; 9th, 10th, and 24th equal at 1; 10th and 29th equal at 1; 24th and 30th equal at 1.

May 11th at 16; 26th at 14.

June 6th at 1; 7th at 12; 8th at 2; 9th at 1; 10th at 13; 15th at 1.

July 12th at 29; 27th at 1.

August 5th at 5; 11th at 1; 19th at 2; 21st at 21; 19th and 21st equal at 1.

September 2nd at 7; 23rd at 2; 24th at 20; 2nd and 24th equal at 1.

October 3rd at 1; 6th at 1; 16th at 10; 19th at 11; 21st at 1; 27th at 4; 6th and 19th equal at 1; 19th and 27th equal at 1.

November 3rd at 11; 23rd at 2; 24th at 16; 3rd and 24th equal at 1.

December 6th at 1; 7th at 2; 8th at 2; 13th at 1; 20th at 2; 21st at 21; 7th and 21st equal at 1.

The day in each month on which a heavy fall of rain was most general over the county was therefore:

Jan. 9th	April 24th	July 12th	Oct. 19th
Feb. 10th	May 11th	Aug. 21st	Nov. 24th
Mar. 7th	June 10th	Sept. 24th	Dec. 21st

The number of wet days in the year (average of 28 gauges) was 170, being the mean of our period. Of the total number there were 43 (or 25%) in the winter months, 49 (or 29%) in the spring, 38 (or 22½%) in the summer, and 40 (or 23½%) in the autumn.

The number of wet days in each month, and the deviation from the mean, was as follows:—

Jan.	12 —4	April	20 +7	July	15 +2	Oct.	22 +8
Feb.	16 +1	May	16 +3	Aug.	17 +3	Nov.	8 —8
Mar.	13 —1	June	6 —8	Sept.	10 —3	Dec.	15 =

Distribution of Rainfall throughout the County.—The mean rainfall in the river-basin of the Ouse was 25·71 ins., and in the river-basin of the Thames, 27·29 ins. The following table (Table III) gives the mean fall for each month and for the year in each of the five river-districts represented, and in the county for comparison, and also the difference in the year from the mean of our period.

Table III.—Rainfall in the River Districts.

Months.	Cam.	Ivel.	Thame.	Colne.	Lea.	County.
	ins.	ins.	ins.	ins.	ins.	ins.
January	·95	·98	1·38	1·29	·94	1·09
February	1·80	1·51	2·40	2·16	1·93	2·00
March	1·23	1·40	2·37	2·03	1·63	1·77
April	2·44	2·26	2·96	2·68	2·20	2·41
May	3·46	4·66	4·21	4·14	3·85	4·01
June	2·47	1·59	1·17	1·10	2·31	1·79
July	2·89	5·32	4·49	4·27	4·26	4·29
August	1·54	1·37	2·41	2·48	2·10	2·18
September	2·05	1·94	1·61	1·84	2·06	1·95
October	3·80	3·56	3·87	3·55	3·64	3·62
November	·79	·92	1·21	1·28	·98	1·09
December	·99	·84	1·15	1·48	1·26	1·30
Year	24·41	26·35	29·23	28·30	27·16	27·50
Diff. from 1876–85	—0·09	—0·95	—2·67	—3·00	—0·12	—1·50

The mean fall in the year in each of the minor river-basins, or sub-districts, was as follows:—

		ins.
Cam	Rhee	24·41
Ivel	Hiz	26·35
Thame	Upper Thame	29·23
Colne	Bulbourne	27·91
	Gade	27·45
	Ver	29·08
	Lower Colne	28·09
Lea	Mimram	26·81
	Beane	27·70
	Rib	26·19
	Ash	27·17
	Upper Lea	27·50
	Lower Lea	27·25

The total yearly fall ranged from 24·41 inches at Royston to 30·76 ins. at Kensworth, and the total monthly fall from 0·73 in. at Fanhams Hall, Ware, in November, to 6·86 ins. at Kensworth in July. The greatest fall in any one day was 3·76 ins. at High Down, Hitchin, on the 12th of July.

Distribution of Rainfall in each Month.—The nomenclature used in the following account of the chief falls of rain is the same as in previous reports, falls of at least ½ inch being styled *considerable*, ¾ inch *very considerable*, 1 inch *great*, 1¼ inch *very great*, 1½ inch *heavy*, 1¾ inch *very heavy*, and of 2 inches and upwards *excessive*. This analysis only applies to the 23 stations from which I have returns of the daily rainfall, except when the fall, being at least half an inch, was the maximum in the month.

January.—Very dry. For the first 7 days and from 22nd to 27th (6 days) no rain fell at eighteen stations, and the average at all during each period was scarcely 0·005 in. On 9th the fall was *considerable* at seven stations.

February.—Rather dry, with scarcely any actual rain, most of the amount gauged being due to snow. On 6th the fall was *considerable* at six stations, on 10th *very considerable* at one (Broxbourne) and *considerable* at twelve, and on 11th *considerable* at one.

March.—Rather dry; about half the amount gauged due to snow falling chiefly during the first 8 days. On 7th the fall was *very considerable* at two stations and *considerable* at six, on 8th *considerable* at two, and on 20th at one.

April.—Rather wet, with rain almost daily at most stations except for the 6 days 15th to 20th. On 9th the fall was *considerable* at one station, on 10th at two, and on 24th at three.

May.—Very wet. On 11th the fall was *heavy* at Kensworth (1·50 in.); *very great* at Welwyn (1·45 in.), Red House, Ware (1·45 in.), Hitchin (1·37 in.), High Down (1·32 in.), Bayfordbury (1·32 in.), Datchworth (1·32 in.), and Weston Manor (1·32 in.); *great* at Tring (1·23 in.), St. Albans (1·22 in.), Cowroast (1·21 in.), Rothamsted (1·20 in.), Fanhams Hall, Ware (1·20 in.), Much Hadham (1·19 in.), Royston (1·14 in.), Therfield (1·11 in.), and Throcking (1·10 in.); and *very considerable* at five stations. On 12th the fall was *considerable* at one station, and on 23rd at one. On 26th it was *excessive* at Gorhambury (2·25 ins.) and Rothamsted (2·12 ins.); *very heavy* at Moor Park (1·78 in.); *heavy* at High Down, Hitchin (1·58 in.), Great Gaddesden (1·58 in.), and Bushey Heath (1·58 in.); *very great* at Tring (1·41 in.), Welwyn (1·39 in.), Berkhamsted (1·38 in.), St. Albans (1·38 in.), New Barnet (1·32 in.), and Nash Mills (1·29 in.); *great* at Oaklands, Watford (1·18 in.), Cowroast (1·10 in.), Brocket Hall (1·10 in.), and Cheshunt (1·10 in.); *very considerable* at two stations, and *considerable* at four. On 26th the fall was *very considerable* at Watford and *considerable* at St. Albans.

June.—Rather dry. No rain fell at any station for the first five days; at thirteen stations none fell for the last half of the month; at High Down, Hitchin, no rain fell after the 9th, at Southgate after the 10th, and at Kensworth and Welwyn after the 11th. The fall for the last 15 days averaged only 0·007 in. On 6th the fall was *great* at New Barnet (1·01 in.) and *very considerable* at Southgate; on 7th *very heavy* at Bayfordbury (1·85 in.), *great* at Southgate (1·18 in.), High Down, Hitchin (1·10 in.), Datchworth (1·10 in.), and Fanhams Hall, Ware (1·09 in.), *very considerable* at three stations, and *considerable* at five; on 9th *considerable* at one station; on 10th *very considerable* at four stations and *considerable* at nine; and on 15th *considerable* at one station.

July.—Excessively wet, although no rain fell at any station but two for the first 8 days, making a period of 20 days with no rain at the majority of the stations. More than half the amount for the month fell at most of the stations on one day, the 12th, during a

thunderstorm. On this day, for which I give the record at all our stations,* the fall was *excessive* at High Down, Hitchin (3·76 ins.), Welwyn† (3·50 ins.), Fanhams Hall, Ware (3·50 ins.), Red House, Ware (3·27 ins.), Bayfordbury (3·07 ins.), Rothamsted (3·06 ins.), Datchworth (3·02 ins.), Brocket Hall (3·02 ins.), St. Albans (2·95 ins.), Much Hadham (2·76 ins.), Throcking (2·60 ins.), Kensworth (2·55 ins.), Nash Mills (2·53 ins.), Bennington (2·51 ins.), Cowroast† (2·50 ins.), Hitchin (2·10 ins.), Royston (2·07 ins.), and Therfield (2·03 ins.); *very heavy* at Gorhambury (1·97 in.), Broxbourne (1·90 in.), and Tring (1·89 in.); *heavy* at Weston Manor (1·73 in.) and Cheshunt (1·60 in.); *very great* at Bushey Heath (1·42 in.) and Great Gaddesden (1·30 in.); *great* at Berkhamsted (1·19 in.); *very considerable* at New Barnet (0·89 in.); *considerable* at Southgate (0·72 in.); and comparatively small at Oaklands, Watford (0·45 in.), and Moor Park (0·33 in.). On 13th the fall was *very heavy* at Kensworth (1·88 in.), *very considerable* at Rothamsted, and *considerable* at five stations; on 23rd *great* at St. Albans (1·01 in.), and *considerable* at four stations; and on 27th *very considerable* at Nash Mills, and *considerable* at two stations.

August.—Rather dry. For the last 7 days no rain fell at seven stations, and for the last 6 days none fell at fifteen stations. On 5th the fall was *considerable* at two stations, and on 21st *very considerable* at four, and *considerable* at six.

September.—Rather dry. No rain fell at four stations from 3rd to 18th (16 days), at two from 4th to 18th, at one each from 5th, 6th, and 7th to 18th, and at ten from 8th to 18th. On 2nd the fall was *great* at Cheshunt (1·14 in.), *very considerable* at two stations, and *considerable* at six; and on 24th *very great* at Moor Park (1·34 in.), *great* at Bushey Heath (1·30 in.), *very considerable* at six stations, and *considerable* at sixteen.

October.—Very wet, rain falling nearly every day at most stations. On 16th the fall was *very great* at Therfield (1·36 in.), *very considerable* at two stations, and *considerable* at seven; on 19th *very considerable* at four stations, and *considerable* at nine; and on 27th *very considerable* at Gorhambury.

November.—Very dry. At three stations no rain fell from 4th to 22nd (19 days), and the average for all during this period was only 0·04 in. On 3rd the fall was *considerable* at three stations, on 23rd at two, and on 24th at eight.

December.—Rather dry, but with no long period without rain. The only *considerable* fall was on 13th at Moor Park.

* *I.e.*, including falls, at two stations, of less than half an inch.

† Gauge overflowed; fall estimated from measurement of water in other receptacles.

IX.

MISCELLANEOUS NOTES AND OBSERVATIONS.

Read at Watford, 18th March and 22nd April, 1890.

Meteorology.

Temperature and Rainfall at Hitchin, 1850–89.—In an early volume of our 'Transactions'* there appeared tables by Mr. William Lucas giving the temperature and rainfall of thirty summers and thirty winters at Hitchin, the period being from 1850 to 1879. Having now been favoured by Mr. Lucas with a table giving, from his own observations for the forty years 1850–89, the mean temperature of each month and the maximum and minimum temperature and rainfall of each year, I thought that although the table could not conveniently be reproduced in its entirety in our 'Transactions,' a summary of it might be of interest. Mr. Lucas does not give in his table either the mean monthly or mean annual temperature, or the mean rainfall, for the period. These means I have therefore computed; and with the view of endeavouring to ascertain whether there has been any secular change in the temperature or rainfall, I have also computed the means for each of the four decades. In the following table these means are given so far as relates to the temperature, and I have added the mean temperature of the coldest and the warmest month, and also of the coldest and the warmest year, during the whole period, with the date.

Mean Temperature at Hitchin, 1850–89.

Months	1850–59	1860–69	1870–79	1880–89	1850–89	Coldest Month and Year.		Warmest Month and Year.	
	°	°	°	°	°	°		°	
January	36·3	36·0	36·1	34·9	35·8	28·1	1881	41·0	1866
February	36·4	38·7	37·2	37·0	37·3	27·0	1855	42·5	1867
March.....	39·5	39·5	39·6	38·4	39·2	30·8	1886	44·0	1859
April	44·5	46·9	45·0	44·2	45·2	41·1	1879	50·7	1869
May	50·0	52·4	49·1	51·0	50·6	45·9	1877	56·0	1889
June	58·5	57·6	57·0	57·2	57·6	54·5	1860	62·5	1858
July	61·0	60·1	60·2	60·7	60·5	55·9	1875	65·3	1859
August	60·3	59·3	59·2	59·3	59·5	55·1	1885	62·7	1857
September	55·2	55·5	53·5	54·6	54·7	49·1	1877	60·5	1865
October	48·7	48·7	46·7	45·9	47·5	42·0	1881	52·3	1886
November	40·1	40·0	38·8	41·3	40·0	35·0	1851	46·3	1888
December	37·8	38·3	34·4	36·8	36·8	29·2	1874	44·1	1868
Year	47·4	47·8	46·4	46·8	47·1	43·7	1879	49·5	1868

It will be seen that the mean temperature of the whole forty years is 47°·1, of the first twenty, 47°·6, and of the last twenty,

* 'Trans. Watford Nat. Hist. Soc.,' Vol. II, p. 251.

46°·6. This would appear to indicate a decreasing temperature, but this idea is to some extent qualified when we see that the second decade was 0°·4 warmer than the first, and that the fourth decade was 0°·4 warmer than the third. Again, the warmest year, 1868, nine of the warmest months, and only three of the coldest, were in the first half of the period; and the coldest year, 1879, nine of the coldest months, and only three of the warmest, were in the second half; but if we examine the mean monthly temperature in each decade, we find no regular gradation from warm to cold. Nor do we find any such gradation if we group the months into seasons, as in the following table, which shows that the first decade was characterised by warm summers and autumns, the second by very mild winters and springs with comparatively cool summers, the third by low temperature throughout the year and especially cold autumns, and the fourth by cold winters and springs.

Temperature of the Seasons at Hitchin, 1850–89.

Decades.	Spring. Mar.-Apl.	Summer. May-July.	Autumn. Aug.-Oct.	Winter. Nov.-Jan.	Year.
	°	°	°	°	°
1850–59	44·7	59·9	48·0	36·8	47·4
1860–69	46·3	59·0	48·1	37·7	47·8
1870–79	44·6	58·8	46·3	36·2	46·4
1880–89	44·5	59·1	47·3	36·2	46·8
1850–89	45·0	59·2	47·4	36·7	47·1

The absolute minimum temperature was zero, in 1855, and the absolute maximum was 88°, in 1868.

The mean rainfall for the whole period was 24·80 inches; for the first twenty years, 24·31 ins., and for the last twenty, 25·29 ins., showing an increase of about one inch in the rainfall, as there was a decrease of one degree in the temperature. The mean rainfall for the first decade was 24·70 ins., for the second, 23·92 ins., for the third, 25·54 ins., and for the fourth, 25·05 ins., the relation of each of these amounts to the mean being respectively ½ % less, 4 % less, 3½ % more, and 1 % more. The driest year was 1864, with a fall of 17·16 ins., and the wettest year was 1852, with a fall of 34·11 ins., both extremes thus being in the first half of the period.

It would therefore appear that if the temperature or the rainfall in the north of Hertfordshire is undergoing any secular change, forty years is too short a period to conclusively show it. A connection can clearly be traced between the temperature and the rainfall; cold periods are on the average wet, and warm periods are dry. This is strikingly shown in the second and third decade, one being much the warmest and driest, and the other much the coldest and wettest of the four.—*John Hopkinson, St. Albans.*

Botany.

Hertfordshire Plant-Records, 1886–89.—The following list of flowering plants observed in Hertfordshire during the last four years is compiled from Miss Selby's annual reports, the records of Mr. A. E. Gibbs, and my own reports of our field meetings in the fourth and fifth volumes of our 'Transactions.' With one exception I have only given localities which do not appear in the late Mr. A. R. Pryor's 'Flora of Hertfordshire,' published by our Society in 1887; and I have not included lists of species which have appeared in our 'Transactions,' but only isolated records. Lists of flowering plants collected or observed at our field meetings in 1886 to 1888 will be found in these volumes as follows:—1886, Vol. IV, pp. xxv and xxxii; 1887, Vol. IV, p. li; 1888, Vol. V, p. xxii. There is no list in the reports for the year 1889. In the sequence of species and in the nomenclature the 'Flora of Hertfordshire' is followed, and the pages of that work are referred to.

Helleborus viridis, L. (pp. 12, 497). Lea.—Green Wood, Fairfield's Farm, Sandridge, 1889.—*Gibbs.*

Aquilegia vulgaris, L. (p. 14). Colne.—Chandler's Cross, Watford, 1888.—*Transactions*, Vol. V, p. xx.

Dentaria bulbifera, L. (p. 30). Colne.—Chandler's Cross, Watford, 1888.—*Transactions*, Vol. V, p. xx.

Viscaria vulgaris, Roehl. (p. 59). Colne.—In a field close to Radlett Church, in splendid flower and in a very viscid condition, early in July, 1886; also in 1888.—*Selby.* This is an alien in Herts but a native in Scotland and North Wales.

Silene nutans, L. (p. 62). Colne.—On the branch railway between Harpenden and Redbourn, 1888.—*Transactions*, Vol. V, p. xxv. The only previous record in Herts is on a garden-wall in Dagnall Lane, St. Albans, from which the plant is believed to have long since disappeared.

Cerastium arvense, L. (pp. 67, 565). Colne.—In a field between Aldbury and Tring Station, 1887.—*Transactions*, Vol. IV, p. xlix. On the branch railway between Harpenden and Redbourn, 1888.—*Transactions*, Vol. V, p. xxv.

Alsine tenuifolia, Crantz (p. 73). Colne.—On walls at Harpenden Hall, 1889.—*Gibbs.*

Linum catharticum, L. (p. 77). Lea.—Railway-bank, Leasy Bridge, Wheathamstead, 1889.—*Gibbs.*

Erodium cicutarium, L'Hérit. (pp. 91, 499). Colne.—On railway-bridge, Cross Lane, Harpenden Common, in a very curiously dwarfed form, 1887.—*Gibbs.*

Trifolium subterraneum, L. (pp. 110, 500). Colne.—Sandpit Lane, St. Albans, 1888.—*Transactions*, Vol. V, p. xxi. There are previous records of the plant in this locality for the year 1844.—*Cf.* '*Flora of Hertfordshire*,' p. 110.

Chrysosplenium oppositifolium, L. (pp. 174, 502). Colne.—Beech Bottom, St. Albans, 1886.—*Transactions*, Vol. IV, p. xx.

Viburnum Lantana, L. (p. 198). Lea.—Near Cold Harbour, Harpenden, 1889.—*Gibbs.*

Adoxa Moschatellina, L. (pp. 200, 502). Colne.—Home Wood, Springfield, St. Albans, 1887.—*Transactions*, Vol. IV, p. xliv. Pré Wood, St. Albans, 1888.—*Transactions*, Vol. V, p. xix.

Valeriana dioica, L. (p. 208). Lea.—Near Cold Harbour, Harpenden, 1889.—*Gibbs.*

Centaurea Cyanus, L. (pp. 247, 503). Colne.—In a field at Battler's Green, Aldenham, with white flowers, July, 1886.—*Selby.* Apparently the first Herts record of this species with white flowers.

C. solstitialis, L. (p. 248). Colne.—In a field near Redbourn, 1886.—*Gibbs.* Exhibited at the Redbourn flower-show, 1887.—*Selby.* A casual which has but rarely been found in Herts.

Vinca minor, L. (pp. 272, 504). Colne.—Lye Lane, St. Stephen's, St. Albans, 1887.—*Gibbs.* Red Heath, Watford, 1888.—*Transactions*, Vol. V, p. xxi.

Utricularia vulgaris, L. (p. 339). Lea.—Broxbourne Common, 1888.—*Transactions*, Vol. V, p. xxv.

Daphne Laureola, L. (pp. 364, 507). Colne.—Chandler's Cross, Watford, 1888.—*Transactions*, Vol. V, p. xx.

Narcissus Pseudo-Narcissus, L. (pp. 411, 509). Colne.—Home Wood, Springfield, St. Albans, 1887.—*Transactions*, Vol. IV, p. xliv. Pré Wood, St. Albans, 1888.—*Transactions*, Vol. V, p. xix.

With regard to her first record of *Viscaria vulgaris*, Roehl. (=*Lychnis Viscaria*, L.), Miss Selby says: "The only way in which I can account for its being found in such a curious locality is the fact of a plant brought from Arthur's Seat, Edinburgh, being kept in a pot by some people living about half a mile off, but this plant had been taken away at least two years before I found the plant I speak of" (*i.e.* before the 1886 record).

Miss Selby's reports for previous years will be found in our 'Transactions' as follows:—Report for 1882, Vol. II, p. 237; for 1883, Vol. III, p. 101; for 1884 and 1885, Vol. IV, p. 118.—*John Hopkinson, St. Albans.*

Zoology.

Ornix fagivora in Hertfordshire.—I have much pleasure in reporting the discovery, at Symond's Hyde Wood, near Sandridge, last autumn, of the larva of *Ornix fagivora*, a species which was first announced as British from specimens taken by me near Cambridge a few years since (see 'Entomologists' Monthly Magazine,' vol. xxii, p. 64). It has since been taken, I have been informed, in Herefordshire. *Ornix* is a genus of the Tineina, the larvæ of which, when nearly full fed, turn up the edge of the leaves of their food-plant into a conical cot, within which they feed.

The larvæ of *Ornix fagivora* may be found in September and October on the leaves of beech and probably on those of hornbeam.

My specimens have all been found on beech. Probably an earlier brood of this species (as is the case with allied species) occurs in August, the larvæ of which may be found in June or July.—*A. F. Griffith, Brighton.*

A White Stoat at Hoddesdon.—On the 2nd of February, 1890, the keeper of Highfields Wood, Hoddesdon, brought to me a female stoat, with the fur all white except the usual black at the extremity of the tail, and a few very slight streaks of brown about the nose. I have met with stoats before in this neighbourhood during January and February with their usual coat pied with white, or all white except the head, and I have looked forward to a severe winter to give me a specimen with its complete winter coat. The term "winter coat," however, is not strictly correct, for the colour is not due to a change of fur but to a change of colour in the fur. White stoats are common in the north at this season, but I believe it is unusual to find one so far south during such a mild winter. Bell ('British Quadrupeds,' 2nd ed., p. 199) refers to an experiment made on a Hudson's Bay lemming which had retained its summer fur. The animal was exposed to a temperature of 30° below zero during one night, and the following morning "the fur on the cheeks, and a patch on each shoulder, had become perfectly white." It has occurred to me that the colour of my specimen may have been caused by sudden and great changes of temperature such as we have had this winter, rather than by any extreme cold of long duration.

It is scarcely necessary for me to add that the white stoat is the "ermine" of commerce.—*F. M. Campbell, Hoddesdon.*

X.

CLIMATOLOGICAL OBSERVATIONS TAKEN IN HERTFORDSHIRE IN 1889.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc.

Read at Watford, 18th November, 1890.

Observations have been made in 1889 at the five stations from which the reports for the two previous years were drawn up. In the first of these reports I gave, for comparison, a table showing the mean results of observations at three stations in Hertfordshire for the five years 1882–86; to the present report I add one showing the same at our five stations for the two years 1887 and 1888.

The mean temperature of Hertfordshire in 1889, as deduced from observations at these five stations, was 0°·8 above that of the two previous years, and therefore 1°·0 below the mean of 1882–86. The mean daily range was 0°·5 less than that of 1887–88, and 1°·3 less than that of 1882–86. The extremes of temperature were about the same as in 1888, and therefore again much less than in 1887. The relative humidity, amount of cloud, rainfall, and number of days of rain were rather greater than the mean, both of the two previous years and of the five years 1882–86, and consequently of the seven years 1882–88.

In 1889, therefore, the air was rather cold and humid, the sky rather cloudy, and the rainfall rather heavy and frequent.

ROYSTON.

(London Road.)

Latitude: 52° 2′ 34″ N. Longitude: 0° 1′ 8″ W. Altitude: 301 feet.

Observer: *Hale Wortham, F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	33·9	30·5	37·2	6·7	17·2	50·4	90	7·0	·95	13
Feb.	36·5	30·4	42·7	12·3	18·1	56·1	86	7·3	1·80	15
March	40·1	32·4	47·8	15·4	18·8	62·4	83	7·0	1·23	13
April	45·8	37·2	54·3	17·1	31·8	64·1	86	7·5	2·44	17
May	57·0	47·7	66·3	18·6	37·1	84·0	89	6·8	3·46	18
June	61·0	50·5	71·5	21·0	44·9	84·3	83	5·8	2·47	5
July	61·9	51·9	71·9	20·0	43·6	82·0	82	6·7	2·88	12
August	59·1	48·9	69·3	20·4	43·2	85·0	83	6·4	1·54	15
Sept.	56·6	47·8	65·5	17·8	36·3	79·6	81	6·3	2·06	11
Oct.	48·2	41·4	54·9	13·2	34·9	59·0	94	5·7	3·80	23
Nov.	44·0	38·9	49·2	10·3	25·9	57·0	92	6·6	·79	9
Dec.	37·0	31·9	42·0	10·1	19·9	53·1	91	6·8	·99	15
Year	48·4	40·8	56·0	15·2	17·2	85·0	87	6·7	24·41	166

BERKHAMSTED.

(Rose Bank.)

Latitude: 51° 45′ 40″ N. Longitude: 0° 33′ 30″ W. Altitude: 400 feet.

Observer: *Edward Mawley, F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	35·2	30·1	40·3	10·2	13·1	50·6	95	8·3	1·39	15
Feb.	36·0	30·1	41·9	11·8	12·8	56·4	89	7·3	2·55	18
March	39·9	32·6	47·2	14·6	17·6	59·1	85	7·7	2·13	17
April	44·5	37·2	51·7	14·5	29·9	61·3	83	8·1	2·94	23
May	54·6	46·3	62·9	16·6	37·3	78·1	76	7·3	3·78	16
June	59·5	50·2	68·9	18·7	45·4	79·5	73	6·9	·67	7
July	59·7	51·2	68·1	16·9	42·8	78·7	71	7·0	3·34	16
August	59·1	50·6	67·7	17·1	42·5	81·1	77	6·3	2·28	16
Sept.	55·1	46·6	63·6	17·0	32·5	77·8	80	6·4	1·60	10
Oct.	47·9	41·1	54·7	13·6	31·3	58·7	91	7·2	3·57	22
Nov.	43·3	37·6	48·9	11·3	25·3	59·3	92	7·7	1·39	8
Dec.	36·2	31·0	41·4	10·4	17·8	53·2	95	8·6	1·23	19
Year	47·6	40·4	54·8	14·4	12·8	81·1	84	7·4	26·87	187

ST. ALBANS.

(The Grange.)

Latitude: 51° 45′ 9″ N. Longitude: 0° 20′ 7″ W. Altitude: 380 feet.

Observer: *John Hopkinson, F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	35·2	30·3	40·2	9·9	17·8	51·7	95	8·7	1·15	13
Feb.	36·1	30·3	42·0	11·7	16·8	56·8	87	7·1	1·98	18
March	39·5	33·1	46·0	12·9	20·1	59·7	84	6·7	1·84	16
April	44·7	37·8	51·6	13·8	32·6	62·5	83	7·4	2·47	24
May	55·0	47·6	62·4	14·8	39·2	79·1	77	7·7	4·51	17
June	59·9	51·1	68·8	17·7	44·5	79·2	78	5·4	1·45	6
July	59·7	52·1	67·4	15·3	46·1	78·9	76	7·2	5·36	16
August	59·4	51·4	67·4	16·0	44·0	80·8	80	6·9	2·16	16
Sept.	55·4	48·1	62·8	14·7	36·4	79·0	85	7·0	2·30	8
Oct.	47·8	41·6	54·0	12·4	31·4	59·5	94	6·7	3·71	26
Nov.	43·5	38·8	48·2	9·4	26·0	55·5	92	6·8	1·14	7
Dec.	36·4	30·9	41·9	11·0	19·9	52·0	94	6·8	1·38	19
Year	47·7	41·1	54·4	13·3	16·8	80·8	85	7·0	29·45	186

BENNINGTON.

(Bennington Lodge.)

Latitude: 51° 53′ 45″ N. Longitude: 0° 5′ 20″ W. Altitude: 407 feet.

Observer: *Rev. J. D. Parker, LL.D., F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	35·4	30·9	39·8	8·9	17·7	52·0	93	8·3	1·10	15
Feb.	35·6	30·4	40·8	10·4	15·1	56·1	87	7·2	1·98	17
March	39·9	33·1	46·8	13·7	20·1	58·8	84	7·2	1·43	16
April	44·5	37·3	51·7	14·4	32·3	62·0	83	8·1	2·89	25
May	54·9	47·1	62·6	15·5	38·0	78·4	79	7·1	4·22	19
June	59·8	50·6	69·1	18·5	43·7	80·5	75	6·5	2·09	7
July	59·7	51·5	67·8	16·3	44·9	77·7	73	7·2	4·93	17
August	59·2	51·1	67·3	16·2	43·2	80·5	76	7·1	2·00	18
Sept.	54·9	47·5	62·4	14·9	34·9	75·8	80	6·7	2·13	14
Oct.	47·9	41·5	54·2	12·7	30·4	58·1	89	7·1	2·99	27
Nov.	43·4	38·4	48·4	10·0	25·9	58·5	91	7·9	1·02	15
Dec.	36·2	31·4	41·0	9·6	19·9	52·2	93	7·6	1·37	20
Year	47·6	40·9	54·3	13·4	15·1	80·5	84	7·3	29·15	210

NEW BARNET.

(Gas Works.)

Latitude: 51° 39′ 5″ N. Longitude: 0° 10′ 15″ W. Altitude: 212 feet.

Observer: *T. H. Martin, C.E.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	35·4	29·2	41·7	12·5	17·5	57·8	91	7·4	·87	7
Feb.	36·4	30·5	42·2	11·7	18·2	59·0	90	7·1	1·95	14
March	39·6	31·0	48·2	17·2	12·7	59·0	85	6·7	1·68	14
April	45·2	36·3	54·1	17·8	27·8	64·0	84	7·0	1·37	16
May	55·1	45·0	65·3	20·3	32·0	80·1	81	5·8	3·81	14
June	60·2	49·1	71·2	22·1	39·0	81·5	76	5·4	2·84	5
July	60·8	50·7	71·0	20·3	40·0	81·0	76	6·0	2·70	13
August	59·6	49·3	69·8	20·5	38·5	85·0	77	5·6	2·99	15
Sept.	55·1	45·1	65·2	20·1	29·1	80·0	83	5·9	1·42	9
Oct.	47·7	39·2	56·2	17·0	27·0	60·5	91	5·5	3·71	20
Nov.	42·9	36·5	49·3	12·8	23·8	58·9	88	6·7	·93	6
Dec.	35·7	29·5	41·9	12·4	14·0	53·2	92	7·6	1·29	12
Year	47·8	39·3	56·3	17·0	12·7	85·0	84	6·5	26·56	145

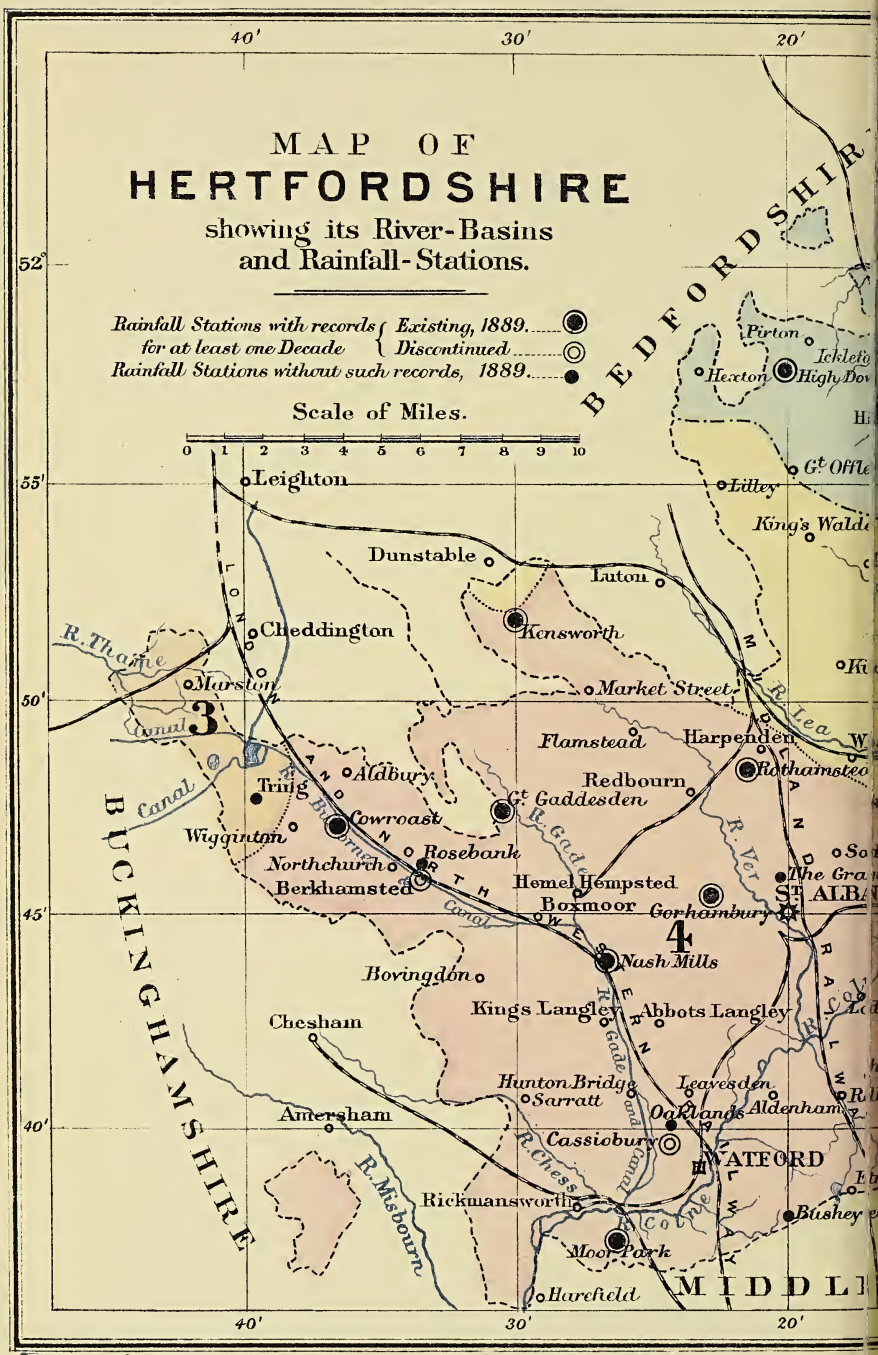
HERTFORDSHIRE.

Means of Climatological Observations (with extremes of temperature) in 1889, at Royston, Berkhamsted, St. Albans, Bennington, and New Barnet.

Months	Temperature of the Air						Humidity	Cloud, 1–10	Rain	
	Means				Extremes					
	Mean	Min.	Max.	Range	Min.	Max.			Am'nt	Days
	°	°	°	°	°	°	%		ins.	
Jan.	35·0	30·2	39·8	9·6	13·1	57·8	93	7·9	1·09	13
Feb.	36·1	30·3	41·9	11·6	12·8	59·0	88	7·2	2·05	16
March	39·8	32·4	47·2	14·8	12·7	62·4	84	7·1	1·66	15
April	44·9	37·2	52·7	15·5	27·8	64·1	84	7·6	2·42	21
May	55·3	46·7	63·9	17·2	32·0	84·0	80	6·9	3·96	17
June	60·1	50·3	69·9	19·6	39·0	84·3	77	6·0	1·90	6
July	60·4	51·5	69·2	17·7	40·0	82·0	76	6·8	3·84	15
August	59·3	50·3	68·3	18·0	35·3	85·0	79	6·5	2·19	16
Sept.	55·4	47·0	63·9	16·9	29·1	80·0	82	6·5	1·90	10
Oct.	47·9	41·0	54·8	13·8	27·0	60·5	92	6·4	3·76	24
Nov.	43·4	38·0	48·8	10·8	23·8	59·3	91	7·1	1·05	9
Dec.	36·3	30·9	41·6	10·7	18·3	52·7	93	7·5	1·27	17
Year	47·8	40·5	55·2	14·7	12·7	85·0	85	7·0	27·09	179

Results of Climatological Observations, 1887–88.

Stations.	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes					
	Mean	Min.	Max.	Range	Min.	Max.			Am'nt	Days
	°	°	°	°	°	°	%		ins.	
Royston	47·7	39·9	55·6	15·7	12·0	89·4	83	6·4	19·73	154
Berkhamsted	46·6	39·2	53·9	14·7	11·2	85·0	83	7·3	23·67	176
St. Albans	47·1	40·0	54·1	14·1	13·7	86·0	83	6·9	24·06	178
Bennington	46·6	39·7	53·5	13·8	17·2	85·1	83	7·8	21·43	186
New Barnet	46·9	38·0	55·7	17·7	8·0	88·5	83	6·2	21·15	144
County	47·0	39·4	54·6	15·2	8·0	89·4	83	6·9	22·01	168



J. Hopkinson, del.

Edwd Weller, Lith.

MAP OF HERTFORDSHIRE

showing its River-Basins and Rainfall-Stations.

Rainfall Stations with records for at least one Decade { *Existing, 1889.* ◉ / *Discontinued* ◎
Rainfall Stations without such records, 1889. ●

Scale of Miles.

0 1 2 3 4 5 6 7 8 9 10

CAMBRIDGESHIRE
BEDFORDSHIRE
BUCKINGHAMSHIRE
MIDDLESEX
ESSEX

Hinxworth · Ashwell · Royston · Barley · Therfield · Barkway · Baldock · Wallington · Sandon · Pirton · Ickleford · Hexton · Highdown · Hitchin · Weston · Throcking · Graveley · Buntingford · Farneaux Pellham · Gt Offley · Ippollitts · Stevenage · Walkern · Lilley · Gt Munden · Braughing · King's Walden · Albury · St Paul's Walden · Bennington · Standon · Knebworth · Lt Munden · Codicote · Datchworth · Walton · Stortford · Much Hadham · Kimpton · Welwyn · Farnhams Hall · Widford · Flamstead · Harpenden · Wheathamstead · Ware · Sawbridgeworth · Tring · Aldbury · Redbourn · Gt Gaddesden · Rothamsted · Brocket Hall · HERTFORD · Amwell · Stanstead · Harlow · Cowroast · Wigginton · Rosebank · Northchurch · Berkhamsted · Sandridge · The Grange · Bayfordbury · Hoddesdon · Hemel Hempsted · Boxmoor · Gorhambury · ST ALBANS · Hatfield · Essendon · Broxbourne · Nash Mills · Bovingdon · North Mimms · Kings Langley · Abbots Langley · London Colney · Northaw · Cheshunt · Chesham · Shenley · Waltham Cross · Waltham Abbey · Hunton Bridge · Sarratt · Leavesden · Radlett · Amersham · Oaklands · Aldenham · Cassiobury · WATFORD · Chipping Barnet · New Barnet · East Barnet · Elstree · Rickmansworth · Bushey Heath · Totteridge · Southgate · Moor Park · Harefield · Leighton · Dunstable · Luton · Cheddington · Kensworth · Marston · Market Street

1 · 2 · 3 · 4 · 5 · 6

R. Rhee · Ruddry Brook · R. Ivel · R. Hitchin · R. Purwell · Wadesmillbury Brook · R. Quin · R. Rib · R. Stort · R. Beane · R. Lea · R. Mimram · R. Ash · R. Thame · R. Gade · R. Ver · R. Colne · R. Misbourn · R. Chess · R. Brent · New River · Lea and Stort Navigation · Grand Junction Canal · Aylesbury Arm Canal · Wendover Arm Canal · Tring Reservoirs · Wilstone Reservoir · LONDON AND NORTH WESTERN RAILWAY · GREAT NORTHERN RAILWAY · GREAT EASTERN RAILWAY

River-Basins.

OUSE
1. Cam
2. Ivel

THAMES
3. Thame
4. Colne
5. Brent
6. Lea

40′ 30′ 20′ 10′ 0° 10′ — 52° — 55′ — 50′ — 45′ — 40′

J. Hopkinson. del.

Edwd Weller, Lith.

XI.

HALF-A-CENTURY'S RAINFALL IN HERTFORDSHIRE.

By John Hopkinson, F.L.S., F.G.S., F.R. Met. Soc.

Read at Watford, 18th November, 1890.

PLATE III.

In our 'Transactions' for July, 1881 (Vol. I, p. 151), there is a paper by the Rev. C. W. Harvey on the "Rainfall in Hertfordshire, 1840–79," in which he gives the mean monthly and annual rainfall, extremes of rainfall, etc., for each of the four decades included in this period. Another decade having terminated, we have materials for arriving at a knowledge of the mean rainfall in Hertfordshire for the last half-century.

The results in Mr. Harvey's paper were deduced from returns for one station for 1840–49, two for 1850–59, seven for 1860–69, and twelve for 1870–79. For the decade 1880–89 we have complete returns for eighteen stations, showing a very satisfactory increase in continuous observations. The actual number of stations from which returns have been received was 27 in the first year of this decade and 30 in the last year, and the number has varied from 26 to 30. The records, and also those for the five years 1875–79, have been published annually in our 'Transactions,' Mr. Harvey having drawn up the reports for the seven years 1880–86, and those for the eight years 1875–79 and 1887–89 having been contributed by myself.

The accompanying map (Plate III) shows the distribution of 33 rainfall stations, being 30 from which returns for the year 1889 have been received, and 3 for which we have complete records for at least one decade but from which returns are no longer received; these, and also the 18 for which we have continuous records for the decade 1880–89, are distinctively marked. In this map the County is divided into six river-basins, viz. the Cam and Ivel, which are in the drainage-system of the Great Ouse; and the Thame, Colne, Brent, and Lea, which are in that of the Thames.

This paper being intended as supplementary to that by the Rev. C. W. Harvey to which I have alluded, I have adopted his method in giving the results of the investigation in a series of tables preceded by explanatory observations.

Table I.—The river-basins enumerated above are here divided into eighteen minor districts. These are numbered 1 to 18, and the numbers in the first column of Tables III and IV refer to these district numbers. It will be seen that we have continuous records for one district for 50 years, for two districts for 40 years, for six for 30 years, for eight for 20 years, and for twelve for 10 years, and that thirteen are now represented,—the districts still without observers being the Upper Ivel, the Chess, the Upper Colne, the Brent, and the Stort.

Table II gives the mean rainfall for each decade in half a century for the number of stations shown in Table I, and also the mean for the whole period. Owing to the varying number of stations, this may require a slight correction. In the first decade we have one rather wet station, Nash Mills; in the second we have that coupled with a decidedly dry one, Hitchin. The excess in one decade would therefore seem to be approximately compensated by the defect in the other, and afterwards the number of stations is sufficient to give a fairly reliable mean for the county. It may be well, however, to examine this question rather more carefully.

The close agreement between the mean rainfall in 1880–89 as deduced from the returns for our 18 selected stations and from the returns for the whole of our stations (26 to 30), as shown below, proves that the continuous records of the smaller number of stations give as accurate a mean for the whole county for this period as we can expect to obtain. Accepting, then, these 18 stations as our standard to represent the county, it is an easy matter to correlate the returns from a smaller number of stations in the previous decades with the returns for these. The means thus corrected are as follows:—1840–49, 24·83 ins.; 1850–59, 25·81 ins.; 1860–69, 25·88 ins.; 1870–79, 27·53 ins.; to which must be added the mean for 1880–89, 26·74 ins. The mean for half a century for the whole county thus derived is 26·16 ins., being about one per cent. less than that directly derived from the actual means for each decade as given in this table, and this difference is almost entirely due to the comparatively small rainfall at the one station, Nash Mills, in the decade 1840–49. But this decade had generally over the country the average rainfall of the 50 years 1830–79 (see Symons' 'British Rainfall' for 1881, p. 32), and if for 1830–39 we substitute 1880–89, it will have nearly the average for the 50 years 1840–89. I therefore think that it will be best to apply no theoretical correction to the mean values shown in Table II, accepting them as giving a sufficiently near approximation to the actual mean rainfall in Hertfordshire for the half-century 1840–89.

In Table III* is given the mean monthly and annual rainfall for the decade 1880–89 at the eighteen stations for which complete returns for the decade have been received, and also the mean at 27 stations in the wettest year of the period (1880) and at 28 in the driest year (1887). In order to ascertain whether the eighteen stations fairly represent the county, I computed the mean for all the stations (26 to 30) for the decade, with the following result:—

Jan. 1·73	April 1·88	July 2 70	Oct. 3·18
Feb. 1·94	May 2·06	Aug. 1·93	Nov. 2·83
Mar. 1·61	June 2·02	Sept. 2·58	Dec. 2·32

giving for the year 26·78 ins. This differs by only 0·04 in., or 0·15 per cent., from the mean for the 18 stations, a remarkably close agreement, and the greatest difference in any one month is only 0·06 in.

* It is scarcely necessary to state that in this and other tables the amount of rain is expressed in inches.

In Table IV the mean rainfall in each district for three decades is given and is compared with the mean in the county. It will be found, so far as can be ascertained from the material at our disposal, that the rainfall in the river-basin of the Ouse is 10 per cent. in defect of that in the county, the Cam having a defect of 13 per cent. and the Ivel of 7 per cent.; and that the rainfall in the Thames river-basin is $1\frac{1}{2}$ per cent. in excess of the county fall, the Colne having an excess of 7 per cent., and the Lea a defect of 4 per cent. The differences in each district throughout the period agree fairly well, except in the Lower Colne, in which the discrepancy between the decades 1870–79 and 1880–89 is due to the district being represented in the first instance by Cassiobury where the rainfall is rather small, and in the second instance by Moor Park where it is very heavy.

Tables V and VI show that the second half of the year has 12 per cent. more rain than the first half, while the rain only increases 1 per cent. from the first to the second, and 1 per cent. from the third to the fourth quarter; and also that the spring is the driest season and the autumn the wettest, winter having rather more rain than spring, and summer having rather less than autumn.

Tables VII, VIII, and IX give the mean number of wet days and mean rainfall per wet day in each month, quarter, and season, and in the year. The fourth quarter, it will be seen, has the greatest number of wet days, but the third has the heaviest fall per wet day; spring and summer have fewer wet days than autumn and winter, but summer and autumn have more rain per wet day than have winter and spring.

In Tables X and XI, showing the maximum and minimum yearly and monthly fall of rain in each decade, a departure from all the previous tables is made in the inclusion of other stations than those which have continuous records for one decade or more, the object being to give extremes of rainfall wherever they occurred, and thus to illustrate its great variability.

Table XII.—I have here collected from every source to which I have access the falls of at least $2\frac{1}{2}$ inches of rain which have occurred in 24 hours.* The remarkable character of the fall of the 12th of July, 1889, could not perhaps be more clearly shown than in this table, but some allowance should be made for increase in the number of rainfall observers and the probability of there being earlier records of heavy falls of which I have no knowledge.

Table XIII gives particulars of all the stations for which we have records in our 'Transactions.' Of the twenty-one stations with continuous records for at least one decade, from which the mean rainfall for the county is computed, it will be seen that returns are no longer received from three, viz. High Street, Berkhamsted; Cassiobury, Watford; and Stevenage.

The columns in this table headed "Period" form an index

* "Therfield, 1879, August 2nd, 3·03," in Mr. Harvey's table showing falls of 2 inches or more ('Transactions,' Vol. I, p. 158), is omitted, as the figures should be 2·03 (see p. 132 of the same volume).

to our reports on the rainfall, showing the years and the decades for which returns for each rainfall station are given in these reports. The symbols in the last column show the method by which the height of each gauge has been determined, ⩚ signifying that a series of levels has been taken to the gauge from an Ordnance bench-mark, T that the height has been ascertained approximately from the same source, L that levels have been taken to the gauge from some datum other than Ordnance mean sea-level, and B that the height has been taken by the barometer.

TABLE I.—*River Districts and Distribution of Rainfall Stations.*

No.	River Districts.			1840 –49	1850 –59	1860 –69	1870 –79	1880 –89	1889
1	Ouse	*Cam* ...	Rhee	...	...	1	1	1	1
2	Ouse	*Ivel* ...	Upper Ivel ...						
3	Ouse	*Ivel* ...	Hiz	...	1	1	1	2	2
4	Thames	*Thame*	Upper Thame	...	...	...	...	...	1
5	Thames	*Colne*	Chess						
6	Thames	*Colne*	Bulbourne ...	...	...	1	2	1	2
7	Thames	*Colne*	Gade	1	1	1	1	2	2
8	Thames	*Colne*	Ver	...	...	2	3	3	4
9	Thames	*Colne*	Upper Colne						
10	Thames	*Colne*	Lower Colne	...	...	...	1	1	3
11	Thames	*Brent*	Upper Brent						
12	Thames	*Lea* ...	Mimram	...	...	...	...	2	2
13	Thames	*Lea* ...	Beane	...	...	...	1	...	2
14	Thames	*Lea* ...	Rib	...	...	...	...	2	2
15	Thames	*Lea* ...	Ash	...	...	...	1	1	1
16	Thames	*Lea* ...	Stort						
17	Thames	*Lea* ...	Upper Lea ...	...	...	1	1	2	4
18	Thames	*Lea* ...	Lower Lea ...	...	...	...	...	1	4
				1	2	7	12	18	30

TABLE II.—*Mean Rainfall for Half a Century* (1840–89).

Months.	1840–49	1850–59	1860–69	1870–79	1880–89	1840–89
January	2·24	2·20	2·80	2·58	1·71	2·31
February	1·92	1·19	1·67	1·82	1·95	1·71
March	1·51	1·25	2·04	1·67	1·58	1·61
April	1·54	1·88	1·50	2·05	1·91	1·78
May	2·08	2·22	2·18	2·13	2·06	2·13
June	1·71	2·06	2·39	2·34	1·99	2·10
July	2·12	3·15	1·86	2·64	2·74	2·50
August	2·30	2·55	2·55	2·60	1·92	2·38
September	2·45	2·00	2·47	2·64	2·60	2·43
October	3·34	3·22	2·39	2·56	3·18	2·94
November	2·85	2·23	2·10	2·76	2·84	2·56
December	1·76	1·55	2·16	2·18	2·26	1·98
Year	25·82	25·50	26·11	27·97	26·74	26·43

TABLE III.—*Mean Rainfall at Eighteen Stations in Hertfordshire for the Decade* 1880–1889, *with the Mean for the Wettest and the Driest Year of the Decade.*

No.	STATION.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1	Royston	1·32	1·62	1·28	1·77	1·81	2·02	2·28	1·86	2·27	2·88	2·44	1·95	23·50
3	Hitchin	1·54	1·75	1·34	1·79	1·95	1·05	2·72	1·82	2·50	3·07	2·68	2·03	25·04
,,	,, High Down	1·52	1·83	1·30	1·96	2·07	1·91	2·97	1·76	2·60	3·00	2·55	2·04	25·51
6	Tring—Cowroast	2·11	2·27	1·90	2·01	2·25	1·98	2·91	1·76	2·89	3·57	3·16	2·79	29·60
7	Great Gaddesden	1·91	2·07	1·64	1·99	2·15	1·79	2·84	1·99	3·04	3·31	2·92	2·42	28·07
,,	Hemel Hempstead—Nash Mills	1·89	2·13	1·88	2·05	2·23	2·08	2·69	2·00	2·76	3·45	3·18	2·51	28·85
8	Kensworth—The Grove	1·92	2·12	1·67	1·95	2·13	1·97	3·09	1·97	2·86	3·46	2·82	2·36	28·32
,,	Harpenden—Rothamsted	1·90	2·08	1·61	2·03	2·19	2·26	2·83	2·01	2·81	3·41	3·02	2·49	28·64
,,	St. Albans—Gorhambury	2·07	2·31	1·74	1·92	2·35	2·18	2·44	1·94	2·61	3·35	3·02	2·45	28·36
10	Rickmansworth—Moor Park	2·15	2·45	2·01	2·26	2·44	2·41	2·60	2·10	2·89	3·42	3·43	2·82	30·98
12	Welwyn Rectory	1·82	1·90	1·49	1·95	2·11	2·00	2·77	1·96	2·48	3·21	2·71	2·16	26·56
,,	Datchworth Rectory	1·53	1·72	1·36	1·81	1·97	1·73	2·70	1·72	2·44	3·00	2·67	1·96	24·61
14	Therfield Rectory	1·41	1·68	1·39	1·97	2·06	2·06	2·69	2·03	2·61	3·12	2·59	1·94	25·55
,,	Throcking Rectory	1·38	1·75	1·39	1·70	1·83	1·65	2·83	1·89	2·43	2·99	2·67	2·01	24·52
15	Much Hadham	1·54	1·88	1·56	1·81	1·84	2·03	2·76	1·95	2·43	3·00	2·89	2·29	25·98
17	Hertford—Bayfordbury	1·56	1·84	1·61	1·70	1·88	1·85	2·70	1·67	2·31	2·96	2·78	2·18	25·04
,,	Ware—Red House	1·43	1·65	1·48	1·72	1·84	1·91	2·81	1·90	2·34	2·79	2·61	1·95	24·33
18	East Barnet—Southgate	1·78	2·09	1·86	2·05	2·01	2·09	2·63	2·17	2·46	3·25	2·99	2·40	27·78
	Mean for the County	1·71	1·95	1·58	1·91	2·06	1·99	2·74	1·92	2·60	3·18	2·84	2·26	26·74
	Wettest Year, 1880	·40	2·60	·95	2·10	·65	2·55	5·20	·85	4·75	5·45	2·50	3·00	31·00
	Driest Year, 1887	1·93	·74	1·62	1·22	2·34	·73	·82	1·28	2·92	1·58	3·12	1·43	19·73

TABLE IV.—*Mean Rainfall in each District, with its relation to County Mean.*

No.	River District.	1860-69.	%	1870-79.	%	1880-89.	%
1	*Cam* ... Rhee	23·47	− 10	23·55	− 16	23·50	− 12
3	*Ivel* ... Hiz	23·89	− 9	25·61	− 8	25·27	− 5
6	*Colne*... Bulbourne ...	29·20	+ 12	31·00	+ 11	29·60	+ 10
7	*Colne*... Gade	26·29	+ 1	28·59	+ 2	28·46	+ 6
8	*Colne*... Ver	27·45	+ 5	29·56	+ 6	28·44	+ 6
10	*Colne*... Lower Colne			27·63	− 1	30·98	+ 16
12	*Lea* ... Mimram					25·58	− 4
13	*Lea* ... Beane			26·25	− 6		
14	*Lea* ... Rib					25·04	− 6
15	*Lea* ... Ash			26·24	− 6	25·98	− 3
17	*Lea* ... Upper Lea ..	25·01	− 4	27·10	− 3	24·69	− 8
18	*Lea* ... Lower Lea ...					27·78	+ 4

TABLE V.—*Mean Rainfall in each Quarter, with its relation to Annual Mean.*

Decades.	1st Quarter.	%	2nd Quarter.	%	3rd Quarter.	%	4th Quarter.	%
1840–49.....	5·67	22	5·33	21	6·87	26	7·95	31
1850–59.....	4·64	18	6·16	24	7·70	30	7·00	28
1860–69.....	6·51	25	6·07	23	6·88	27	6·65	25
1870–79	6 07	22	6·52	23	7·88	28	7·50	27
1880–89.....	5·24	20	5·96	22	7·26	27	8·28	31
Mean	5·63	21½	6·01	22½	7·32	27½	7·47	28½

TABLE VI.—*Mean Rainfall in each Season, with its relation to Annual Mean.*

Decades.	Spring.	%	Summer.	%	Autumn.	%	Winter.	%
1840–49.....	5·13	20	6·13	24	8·64	33	5·92	23
1850–59.....	5·35	21	7·76	30	7·45	29	4·94	20
1860–69	5·72	22	6·80	26	6·96	27	6·63	25
1870–79	5·85	21	7·58	27	7·96	29	6·58	23
1880–89	5·55	21	6·65	25	8·62	32	5·92	22
Mean	5·52	21	6·98	26	7·93	30	6·00	22½

TABLE VII.—*Mean Number of Wet Days and Mean Rainfall per Wet Day in each Month and in the Year.*

MONTHS.	NUMBER OF WET DAYS.			RAINFALL PER WET DAY.		
	1870–79	1880–89	1870–89	1870–79	1880–89	1870–89
January	16	14	15	·16	·12	·14
February	15	13	14	·12	·15	·14
March	14	11	13	·11	·14	·13
April	13	14	13	·15	·14	·15
May	13	12	13	·16	·17	·16
June	14	11	13	·17	·18	·17
July	13	15	14	·20	·18	·19
August	14	13	13	·15	·15	·15
September	13	13	13	·20	·20	·20
October	15	16	15	·16	·20	·18
November	16	16	16	·17	·18	·17
December	15	16	16	·14	·14	·14
Year	171	164	168	·16	·16	·16

TABLE VIII.—*Mean Number of Wet Days and Mean Rainfall per Wet Day in each Quarter.*

QUARTERS.	NUMBER OF WET DAYS.			RAINFALL PER WET DAY		
	1870–79	1880–89	1870–89	1870–79	1880–89	1870–89
1st Quarter	45	38	42	·13	·14	·14
2nd Quarter	40	37	39	·16	·16	·16
3rd Quarter	40	41	40	·18	·18	·18
4th Quarter	46	48	47	·16	·17	·16

TABLE IX.—*Mean Number of Wet Days and Mean Rainfall per Wet Day in each Season.*

SEASONS.	NUMBER OF WET DAYS.			RAINFALL PER WET DAY.		
	1870–79	1880–89	1870–89	1870–79	1880–89	1870–89
Spring	40	37	39	·14	·15	·15
Summer	41	39	40	·17	·17	·17
Autumn	44	45	44	·18	·19	·18
Winter	46	43	45	·14	·14	·14

TABLE X.—*Maximum and Minimum Yearly Fall in each Decade.*

Decades.	Maximum Fall.			Minimum Fall.		
	Year.	Station.	Amount.	Year.	Station.	Amount.
1st.	1841	Nash Mills.....	32·10	1840	Nash Mills.....	21·44
2nd.	1852	Nash Mills.....	41·14	1854	Hitchin	17·13
3rd.	1860	Berkhamsted	36·34	1864	Royston	16·62
4th.	1879	Moor Park.....	42·56	1870	Hoddesdon.....	16·83
5th.	1880	Moor Park.....	40·27	1884	Barley	15·79

TABLE XI.—*Maximum and Minimum Monthly Fall in each Decade.*

Decades.	Maximum Fall.			Minimum Fall.		
	Month.	Station.	Amount.	Month.	Station.	Amount.
1st.	Oct. 1846	Nash Mills ...	6·36	May 1848	Nash Mills...	0·21
2nd.	Nov. 1853	Nash Mills ...	6·95	Feb. 1857	Hitchin	0·11
3rd.	Oct. 1865	Rothamsted...	7·35	Sept. 1865	Rothamsted..	0·17*
4th.	Aug. 1878	Bayfordbury..	7·64	Apl. 1870	Cassiobury ..	0·08
5th.	Aug. 1881	Gt. Gaddesden	7·23	July 1884	Hitchin	0·10

TABLE XII.—*Falls of at least 2½ inches which have occurred in 24 hours.*

Date.	Station.	Am'nt.	Date.	Station.	Am'nt.
1857, Oct. 22	Hitchin	3·09	1889, July 12	Rothamsted	3·06
,, ,,	Berkhamsted..	2·65	,, ,,	St. Albans§ (1)..	2·95
1868, Aug. 19	Stevenage.....	2·90	,, ,,	,, (2)..	2·54
1874, July 11	Welwyn	2·50	,, ,,	Danesbury‡ ..	3·85
1878, Apl. 10	Southgate.....	2·56	,, ,,	Datchworth	3·02
,, June 30	Watford†.....	2·77	,, ,,	Marden Hill‖ ..	3·91
,, ,,	Bayfordbury...	3·68	,, ,,	Bennington	2·51
1879, Aug. 2	Royston	3·00	,, ,,	Throcking	2·60
,, ,,	Berkhamsted..	2·50	,, ,,	Brocket Hall	3·02
1880, July 14	Ware	2·57	,, ,,	Bayfordbury.....	3·07
1888, June 26	Rothamsted..	3·24	,, ,,	Hertford	3·46
,, ,,	Danesbury‡...	2·58	,, ,,	Ware	3·27
1889, July 12	High Down...	3·76	,, ,,	Fanhams Hall .	3·50
,, ,,	Nash Mills ...	2·53	,, ,,	St. Margarets ..	3·00
,, ,,	Kensworth ...	2·55	,, ,,	Much Hadham..	2·76

* And at Hitchin in July, 1864. † At Oaklands. ‡ Near Welwyn.
§ (1) The Grange; (2) Torrington House. ‖ Near Tewin.

TABLE XIII.—*Rainfall Stations for which Returns of the Rainfa*

River Basins.	Station.	Observer.	
OUSE. Ivel. Cam. 1. Rhee	Barley	Rev. C. O. Miles	
	Royston	Hale Wortham	1
	Odsey	Ernest O. Fordham	
	Odsey Grange	H. George Fordham	1
OUSE. Ivel. 3. Hiz	Hitchin	William Lucas	1
	,, High Down	Joseph Pollard	1
THAMES. Thame. 4. Upper Thame	Tring Vicarage	Rev. W. Quennell	
THAMES. Colne. 6. Bulbourne	Tring—Cowroast	Hubert Thomas, C.E.	1
	Berkhamsted—Rosebank	Edward Mawley	
	,, High Street	William Squire	
	,, Ashlyns	William Longman	
THAMES. Colne. 7. Gade	Great Gaddesden Vicarage	Rev. W. T. Drake	1
	Hemel Hempstead—Nash Mills	J. Dickinson & Co.	1
THAMES. Colne. 8. Ver	Kensworth—The Grove	Miss S. Grace Jones	1
	Harpenden—Rothamsted	Lawes and Gilbert	1
	St. Albans—The Grange	John Hopkinson	
	,, Gorhambury	Rt. Hon. Earl of Verulam	1
THAMES. Colne. 10. Lower Colne	Watford—Cassiobury	Rt. Hon. Earl of Essex	
	,, Oaklands	Edward Harrison	1
	,, Holly Bank	John Hopkinson	
	,, Wansford House	,, ,,	
	,, Watford House	Alfred T. Brett, M.D.	1
	,, Harwoods Farm	W. Swanston	
	,, Bushey Station	Robert Savill	
	,, Bushey Heath	Forrester Scott	
	Rickmansworth—Moor Park	Rt. Hon. Lord Ebury	1
THAMES. Lea. 12. Mimram	Welwyn Rectory	Rev. Canon Wingfield	1
	Datchworth Rectory	Rev. J. Wardale	1
THAMES. Lea. 13. Beane	Knebworth Rectory	Rev. F. G. Jenyns	1
	Stevenage	Rev. J. O. Seager	
	,, Weston Manor	Marlborough R. Pryor	
THAMES. Lea. 14. Rib	Bennington Lodge	Rev. J. D. Parker, LL.D.	
	Therfield Rectory	Rev. J. G. Hale	
	Throcking Rectory	Rev. C. W. Harvey	
	Aspenden	Rev. A. P. Sanderson	
THAMES. Lea. 15. Ash	Much Hadham	T. Woodham Mott †	
	Ware—Fanhams Hall	Miss Joyce Croft	
THAMES. Lea. 17. Upper Lea	Hatfield—Brocket Hall	J. Landon ‡	
	Hertford—Bayfordbury	W. Clinton Baker	
	Ware—Red House §	Joseph Francis, C.E. ‖	
	,, Fanhams Hall	Miss Joyce Croft	
THAMES. Lea. 18. Lower Lea	Hoddesdon	A. C. McKenzie	
	,, Fieldes Weir	Beardmore & Barnes	
	Broxbourne	G. J. Newbery	
	Cheshunt College	Rev. Dr. Reynolds	
	New Barnet—Gasworks	T. H. Martin, C. E.	
	Southgate—The Lawns	George A. Church	

* There are two other gauges here, one 8 inches in diameter, and the other $\frac{1}{1000}$ of

‡ 1878–84, Hon. H. F. Cowper, M.P. § The New Riv

Period.		Latitude.	Longitude.	Diameter of Gauge.	Height of top of Gauge above	
Years.	Decades.				Ground.	Sea-level.
		° ′ ″	° ′ ″	ins.	ft. ins.	ft.
883, 84		52 1 0 N	0 3 0 E	5	1 0	322
876–89	3 1860–89	52 2 34 N	0 1 8 W	8	0 6	269
881, 82		52 1 25 N	0 6 40 W	5	0 10	257
877–87		52 1 28 N	0 6 41 W	5	1 0	263
876–89	4 1850–89	51 57 0 N	0 16 20 W	5	2 1	238
878–89	1 1880–89	51 57 40 N	0 20 0 W	5	1 1	422
882–89		51 47 33 N	0 39 25 W	5	1 0	442
876–89	2 1870–89	51 47 0 N	0 36 30 W	10	4 2	345
885–89		51 45 40 N	0 33 30 W	8	1 0	401
876–84	2 1860–79	51 45 30 N	0 33 30 W	8	1 6	370 B
876		51 44 55 N	0 35 50 W	5	1 0	550
877–89	1 1880–89	51 47 20 N	0 30 30 W	8	1 0	426
875–89	5 1840–89	51 44 0 N	0 26 40 W	12	3 9	237
876–89	2 1870–89	51 51 30 N	0 30 0 W	5	1 0	630 B
876–89	3 1860–89	51 48 10 N	0 21 30 W	5*	0 9	420
887–89		51 45 9 N	0 20 6 W	5	1 0	380
876–89	3 1860–89	51 45 20 N	0 23 0 W	6 sqr.	2 6	413
875–77	1 1870–79	51 40 10 N	0 24 55 W	5	1 3	258
875–81, 87–89		51 40 5 N	0 24 20 W	5	5 6	273
876, 77		51 40 5 N	0 24 10 W	5	1 0	270
878–86		51 39 41 N	0 23 30 W	5	1 0	221
875–77, 79–88		51 39 25 N	0 23 35 W	5	1 0	240
875, 76		51 39 10 N	0 24 20 W	5	1 3	235
876–82		51 38 50 N	0 22 50 W	5	0 6	220
879, 81, 82, 89		51 38 0 N	0 20 0 W	5	1 0	480
876–89	1 1880–89	51 37 30 N	0 26 20 W	5	2 0	340
876–89	1 1880–89	51 49 50 N	0 12 30 W	5	0 6	228
878–89	1 1880–89	52 2 0 N	0 10 0 W	5	1 0	386
877–87		51 52 30 N	0 12 30 W	5	1 0	391
876–83	1 1870–79	51 55 5 N	0 11 40 W	8	2 0	319
889		51 57 20 N	0 9 30 W	5	0 9	500?
884–89		51 53 45 N	0 5 20 W	5	1 0	408
877–89	1 1880–89	52 1 0 N	0 3 0 W	5	4 3	500
880–89	1 1880–89	51 57 5 N	0 3 0 W	5	1 0	484
876–78		51 56 10 N	0 1 40 W	5	1 1	329
876–89	2 1870–89	51 51 24 N	0 4 38 E	5	1 0	222 B
882–84		51 49 0 N	0 1 0 W	5	1 0	253
878–84, 89		51 48 0 N	0 14 0 W	8	1 0	250?
876–89	3 1860–80	51 46 30 N	0 5 30 W	8	1 2	250
877–89	1 1880–80	51 46 0 N	0 6 0 W	12	3 0	114
883–89		51 49 30 N	0 1 30 W	8	1 0	253
881–83		51 45 40 N	0 0 30 W	8	1 6	147
876, 77		51 45 40 N	0 0 50 E	20	3 0	82
888–89		51 44 30 N	0 1 0 W	5	1 0	118
888–89		51 42 5 N	0 2 50 W	5	1 1	94
887–89		51 39 5 N	0 10 15 W	8	0 9	212
877–89	1 1889–89	51 37 40 N	0 8 0 W	5	0 6	240

re in area.
mpany's gauge.

† Previously to 1881, Rev. H. S. Mott.
‖ Previously to 1883, James Muir, C.E.

[*To follow p.* 88.

TABLE XIII.—*Rainfall Stations for which Returns of the Rainfall have been published by the Hertfordshire Natural History Society.*

River Basins.		Station.	Observer.	Period. Years.		Period. Decades.		Latitude.	Longitude.	Diameter of Gauge.	Height of top of Gauge above Ground.	Height of top of Gauge above Sea-level.	
								° ′ ″	° ′ ″	ins.	ft. ins.	ft.	
OUSE.	Ivel. Cam.	1. Rhee	Barley	Rev. C. O. Miles	2	1883, 84		52 1 0 N	0 3 0 E	5	1 0	322	
			Royston	Hale Wortham	14	1876-89	3	1860-89	52 2 34 N	0 1 8 W	8	0 6	269
			Odsey	Ernest O. Fordham	2	1881, 82			52 1 25 N	0 6 40 W	5	0 10	257
			Odsey Grange	H. George Fordham	11	1877-87			52 1 28 N	0 6 41 W	5	1 0	263
		3. Hiz	Hitchin	William Lucas	14	1876-89	4	1850-89	51 57 0 N	0 16 20 W	5	2 1	238
			,, High Down	Joseph Pollard	12	1878-89	1	1880-89	51 57 40 N	0 20 0 W	5	1 1	422
THAMES.	Thame.	4. Upper Thame	Tring Vicarage	Rev. W. Quennell	8	1882-89			51 47 33 N	0 39 25 W	5	1 0	442 T
	Colne.	6. Bulbourne	Tring—Cowroast	Hubert Thomas, C.E.	14	1876-89	2	1870-89	51 47 0 N	0 36 30 W	10	4 2	345 L
			Berkhamsted—Rosebank	Edward Mawley	5	1885-89			51 45 40 N	0 33 30 W	8	1 0	401
			,, High Street	William Squire	9	1876-84	2	1860-79	51 45 30 N	0 33 30 W	8	1 6	370 B
			,, Ashlyns	William Longman	1	1876			51 44 55 N	0 35 50 W	5	1 0	550
		7. Gade	Great Gaddesden Vicarage	Rev. W. T. Drake	13	1877-89	1	1880-89	51 47 20 N	0 30 30 W	8	1 0	426 T
			Hemel Hempstead—Nash Mills	J. Dickinson & Co.	15	1875-89	5	1840-89	51 44 0 N	0 26 40 W	12	3 9	237
		8. Ver	Kensworth—The Grove	Miss S. Grace Jones	14	1876-89	2	1870-89	51 51 30 N	0 30 0 W	5	1 0	630 B
			Harpenden—Rothamsted	Lawes and Gilbert	14	1876-89	3	1860-89	51 48 10 N	0 21 30 W	5*	0 9	420 T
			St. Albans—The Grange	John Hopkinson	3	1887-89			51 45 9 N	0 20 6 W	5	1 0	380 T
			,, Gorhambury	Rt. Hon. Earl of Verulam	14	1876-89	3	1860-89	51 45 20 N	0 23 0 W	6 sqr.	2 6	413
		10. Lower Colne	Watford—Cassiobury	Rt. Hon. Earl of Essex	3	1875-77	1	1870-79	51 40 10 N	0 24 55 W	5	1 3	258
			,, Oaklands	Edward Harrison	10	1875-81, 87-89			51 40 5 N	0 24 20 W	5	5 6	273 T
			,, Holly Bank	John Hopkinson	2	1876, 77			51 40 5 N	0 24 10 W	5	1 0	270 T
			,, Wansford House	,, ,,	9	1878-86			51 39 41 N	0 23 30 W	5	1 0	221 T
			,, Watford House	Alfred T. Brett, M.D.	13	1875-77, 79-88			51 39 25 N	0 23 35 W	5	1 0	240 T
			,, Harwoods Farm	W. Swanston	2	1875, 76			51 39 10 N	0 24 20 W	5	1 3	235
			,, Bushey Station	Robert Savill	7	1876-82			51 38 50 N	0 22 50 W	5	0 6	220
			,, Bushey Heath	Forrester Scott	4	1879, 81, 82, 89			51 38 0 N	0 20 0 W	5	1 0	480
			Rickmansworth—Moor Park	Rt. Hon. Lord Ebury	14	1876-89	1	1880-89	51 37 30 N	0 26 20 W	5	2 0	340
	Lea.	12. Mimram	Welwyn Rectory	Rev. Canon Wingfield	14	1876-89	1	1880-89	51 49 50 N	0 12 30 W	5	0 6	228 T
			Datchworth Rectory	Rev. J. Wardale	12	1878-89	1	1880-89	52 2 0 N	0 10 0 W	5	1 0	386 T
		13. Beane	Knebworth Rectory	Rev. F. G. Jenyns	11	1877-87			51 52 30 N	0 12 30 W	5	1 0	391
			Stevenage	Rev. J. O. Seager	8	1876-83	1	1870-79	51 55 5 N	0 11 40 W	8	2 0	319 L
			,, Weston Manor	Marlborough R. Pryor	1	1889			51 57 20 N	0 9 30 W	5	0 9	500 ?
			Bennington Lodge	Rev. J. D. Parker, LL.D.	6	1884-89			51 53 45 N	0 5 20 W	5	1 0	408
		14. Rib	Therfield Rectory	Rev. J. G. Hale	13	1877-89	1	1880-89	52 1 0 N	0 3 0 W	5	4 3	500
			Throcking Rectory	Rev. C. W. Harvey	10	1880-89	1	1880-89	51 57 5 N	0 3 0 W	5	1 0	484 T
			Aspenden	Rev. A. P. Sanderson	3	1876-78			51 56 10 N	0 1 40 W	5	1 1	329 T
		15. Ash	Much Hadham	T. Woodham Mott †	14	1876-89	2	1870-89	51 51 24 N	0 4 38 E	5	1 0	222 B
			Ware—Fanhams Hall	Miss Joyce Croft	3	1882-84			51 49 0 N	0 1 0 W	5	1 0	253 T
			Hatfield—Brocket Hall	J. Landon ‡	8	1878-84, 89			51 48 0 N	0 14 0 W	8	1 0	250 ?
		17. Upper Lea	Hertford—Bayfordbury	W. Clinton Baker	14	1876-89	3	1860-80	51 46 30 N	0 5 30 W	8	1 2	250
			Ware—Red House §	Joseph Francis, C.E.	13	1877-89	1	1880-80	51 46 0 N	0 6 0 W	12	3 0	114 T
			,, Fanhams Hall	Miss Joyce Croft	7	1883-89			51 49 30 N	0 1 30 W	8	1 0	253 T
		18. Lower Lea	Hoddesdon	A. C. McKenzie	3	1881-83			51 45 40 N	0 0 30 W	8	1 6	147
			,, Fieldes Weir	Beardmore & Barnes	2	1876, 77			51 45 40 N	0 0 50 E	20	3 0	82
			Broxbourne	G. J. Newbery	2	1888-89			51 44 30 N	0 1 0 W	5	1 0	118 T
			Cheshunt College	Rev. Dr. Reynolds	2	1888-89			51 42 5 N	0 2 50 W	5	1 1	94
			New Barnet—Gasworks	T. H. Martin, C. E.	3	1887-89			51 39 5 N	0 10 15 W	8	0 9	212
			Southgate—The Lawns	George A. Church	13	1877-89	1	1889-89	51 37 40 N	0 8 0 W	5	0 6	240 T

* There are two other gauges here, one 8 inches in diameter, and the other $\frac{1}{1000}$ of an acre in area.

‡ 1878-84, Hon. H. F. Cowper, M.P.

§ The New River Company's gauge.

† Previously to 1881, Rev. H. S. Mott.

‖ Previously to 1883, James Muir, C.E.

[*To follow p.* 88.

XII.

NOTES ON BIRDS OBSERVED IN HERTFORDSHIRE DURING THE YEAR 1889.

By George Rooper, F.Z.S.

Read at Watford, 18th November, 1890.

I think that since the death of our late lamented friend, Mr. Littleboy, whose office of Ornithological Recorder I so unworthily fill, rare birds have altogether ceased to visit this part of the country. At any rate, I have heard of very few. Were it otherwise, a dry record of arrival and departure of visitants more or less uncommon, might, however short, prove somewhat tedious in the recital. I have ventured therefore to expand my record by adding some particulars of the life and habits of the birds referred to, and of their immediate relations, making my address, in some measure, a supplement to the one you were kind enough to listen to last year, when I discoursed about "Birds, their Nests and Habits."

To commence with the records of our rarer visitants, I may mention that that indefatigable and accurate observer, Mr. Henry Lewis of St. Albans, reported having seen on the 14th of April a lesser spotted woodpecker (*Picus minor*), now a rare bird, though formerly plentiful. His brother, about the same time, observed a "Java sparrow," feeding with a flock of common sparrows, who must have felt honoured by such recognition of their cousinship. I think that this bird must have escaped from confinement, and cannot therefore admit him even as a "rare visitant" to the County of Hertford. The woodpecker I may refer to later on.

A hawfinch was caught by Mr. Southgate in March. I hope he let him go again, but he could hardly be blamed if he did not, for the hawfinch is a very mischievous bird in the garden. Like the bullfinch, his favourite food in the early spring consists of fruit-buds. I have at least two pairs of hawfinches in my garden; besides the mischief they do, they cause much litter by biting off the new shoots of the yew, whilst feeding on the berries. The hawfinch is much more common than is generally supposed, but, although larger than the chaffinch, it is not unlike that bird, and is frequently mistaken for it. The bird was formerly considered to be a winter visitant only, but is now known to breed commonly in this country, especially in Epping Forest.

Last winter Miss Selby observed a white robin near Garstons; and Mr. Selby informed me that a "white lark" was frequently seen amongst a flock of those birds in one of his fields. This must have been the snow-bunting or snow-flake (*Plectrophanes Laponica*), a rare bird in this country, allied both to the larks and the buntings, and resembling both in shape and habit. When observed, it has always been under similar circumstances to those recorded by Mr. Selby, *viz.* in the company of a flock of larks.

Mr. Lewis reported the arrival of the cuckoo on the 12th of

April; * Mr. Hopkinson heard it at St. Albans on the 22nd. The swallow was first seen on the 7th, and the yellow wagtail on the 14th. Miss Selby, however, saw a pair of swallows on the 1st of April, an unusually early date, but, as is frequently the case, they disappeared directly afterwards. These birds were, as a rule, both scarce and late last year. In Scotland the first I saw was on the 3rd of May. The chiffchaff, the earliest of our summer visitants, was heard on the 12th of April.

Cuckoos were unusually numerous. Young cuckoos were hatched in all directions about here; two I heard of at Cassiobury, one at High Elms, one in my own garden, and very many others. The cuckoo is a plain-spoken, trustworthy bird, but more fibs are told about him than of any other bird I know. "Cuckoo tales" were unusually rife last year—mostly untrue, though not intentionally so. Two gamekeepers deposed to having *found their nests*, and one of them actually saw the old bird *sitting on its nest*. Gamekeepers are not ornithologists, and I have little doubt but that they mistook the goatsucker (*Caprimulgus*) for the cuckoo, to which the bird bears some resemblance. A writer in the 'Times' heard the bird's familiar cry in the depth of winter; another saw the bird fly out of a log of wood brought in for burning at Christmas, and heard him cry "Cuckoo." The first correspondent did not pretend to have *seen* the bird, and, considering how easily the familiar note is imitated, no great weight need be given to the report. The other story was a simple hoax. Besides that a cuckoo could not live for a day in this climate in the winter, he certainly would not cry "Cuckoo" if he did; that "wandering voice" is hushed in June, or at the latest in July.

Another old story was raked up, and found admission into several papers, that the cuckoo assimilates the colour of her egg to that of the bird's in whose nest she lays it! This is nonsense. The colour of the cuckoo's egg, generally a dark olive-green, no doubt varies considerably; it is sometimes blue and sometimes spotted: but she has neither power nor choice in the matter of colour; nor does the bird in whose nest the egg is laid observe or regard the similarity or otherwise to its own eggs. That laid in my garden was in a hedge-sparrow's nest, and was not blue, but spotted, almost like that of the common sparrow. The one at High Elms was in a wagtail's nest, and was described to me as dark green in colour. I am certain that, whatever the colour, the cuckoo had no choice in the matter, nor would the foster-mother make the colour of the egg any objection to its admission into the family circle.

Of curious birds Mr. Lewis records a partially white blackbird, and a white-headed young cuckoo. Mr. Smith wrote that he had observed a "pied rook" on his farm. This was the saddle-back, hooded, or Royston crow (*Corvus cornix*), a first cousin of the carrion crow, with whom he occasionally intermarries, when the

* "The arrival of the cuckoo was *reported to me* from Buntingford on the 12th of April. Its call was heard by Mr. Arthur Dickenson on the 13th of April near Batch Wood, St. Albans."—*H. Lewis.*

young birds, four in number, are in general equally divided in plumage, there being two of each sort. The hooded crow possesses all the bad qualities of the carrion crow; a more mischievous bird, especially on the moors, does not exist. He seeks out the nests of the grouse, from which he takes, one by one, every egg, and he is equally destructive to the young birds. Unlike the hawk, who is contented with a single bird, if big enough to furnish a dinner, he never ceases his murderous onslaught until he has removed every egg, or killed every young bird. What he cannot eat he hides or buries. The hawk is not nearly so mischievous; having made a plentiful meal, he resorts to a tree or rock, and patiently awaits the satisfactory process of digestion.

The nightingale, like the cuckoo, was very numerous last year. The earliest record I have of his song being heard is the 16th of April, and Mr. Lewis was informed, and apparently credits the report, that he was heard to sing as late as the 6th of August, and again on the 21st. I confess I have no faith in either report. Several birds, the thrush especially, frequently imitate the song of the nightingale.

Dr. Brett reported on the 15th of January the murder of two hawks, one a sparrow-hawk, a bird now, alas! as rare as formerly it was common. The other he described as having a spotted breast, and it was no doubt that most useful and harmless bird, the kestrel. Next to the owl, the farmer has no better friend than the kestrel. One, described as a sparrow-hawk, was lately mentioned in the 'Times' as having been seen in Kensington Gardens. The fact that he was "hovering" leads me to think that it was the kestrel, and not the sparrow-hawk, who, I think, never "hovers," and is a much more rare bird. At the same time, a green woodpecker was observed.* Yarrell, in his 'British Birds,' states that formerly all the woodpeckers were common in Kensington Gardens, our fauna at that time containing but three, of which the lesser spotted woodpecker recorded by Mr. Leiws, is the most rare.

Great flights of peewits, or green plovers, passed over Watford immediately before the bad weather we experienced towards the end of January. Gulls, too, were observed in the neighbourhood, a sure sign of the approach of stormy weather.

I saw a pair of gulls flying over Cassiobury Park on the 18th of August, and immediately afterwards we were visited with a spell of bad weather. Walter Scott, a keen observer of nature, in the pathetic ballad of 'Rosabelle,' refers to the habit these birds have of seeking the mainland before a storm:

"To inch and rock the sea-mews fly."

* Gamekeepers and foresters have combined to extirpate this beautiful and harmless bird; the former, on the general principle that all birds bigger than a thrush, and not on the game list, should be destroyed; the latter, under the mistaken notion that it injures the tree by boring holes in it. In fact, the woodpecker's bill is no more capable of puncturing a solid bit of healthy wood than it is of a rock, or a brick wall. When "tapping the hollow beech tree" he is simply searching the decayed timber for the mischievous insects that have caused and perpetuate the mischief.

I do not know that gulls are of any special use in the creation, excepting that they clear the sea and shore of refuse, which would otherwise be objectionable. Ladies have given up the bad habit of wearing their wings in their hats, and they are not good to eat; but I do think that the gull has personally a better chance of material happiness in this world than any other bird or beast. His senses of sight, smell, and hearing are all excellent, especially his sight, which is marvellous. Throw a bit of biscuit as big as a nut into the raging surf in the wake of a large steamer, and the attendant gull descends from a considerable height and picks it up in an instant. He runs and walks with ease and not ungracefully, not waddling like a goose or duck; he swims, buoyant as a cork; and his flight is rapid and powerful. He is blest with a never-failing appetite, which the inexhaustible stores of the sea afford ample opportunity of satisfying. If I had been born a Hindoo, and believed in the metempsychosis, I would have prayed Vishnu to translate me, after death, into the body of a gull.

Last autumn an unhappy rook, riddled with shot, with a broken wing and an injured leg, honoured me by taking up his abode in my garden. I did what I could for him, fed and tended him, and to some extent tamed him; at least he would come to my call for his breakfast and supper. His friends and relations were unremitting in their attention; they came in small flocks every day to visit him. A sentimentalist might have assumed that they came out of a charitable wish to console him in his unhappy position. They did not. Thieves by nature, they came to rob him of his meals. Regardless of his crippled condition, they would buffet the poor bird, and literally take the bread out of his mouth. Rooks are interesting birds to watch, and I observed one fact in connection with them which I have never seen recorded, *viz.* that the old birds feed their young, at least occasionally, through the whole winter—indeed, up to February, when they begin nesting again. I have watched pertinacious young birds following their mothers and bullying them until they have transferred the coveted morsel from their own to their offsprings' gaping beaks.

A raven was recorded as being shot on the borders of this county in January. I have no doubt but that it was an escaped tame one, for the bird is now almost extinct. The raven is the head of the crow family: he has all the bad qualities of the carrion crow, intensified by his greater size and strength. He not only steals eggs, and devours young birds, but will peck the eyes out of a sickly sheep, or murder a weakly lamb. His hoarse cry and savage aspect, as well as his evil deeds, have always caused him to be considered a bird of ill omen—the "fatal raven" Shakespeare calls him. In one of Gay's 'Fables,' the old woman riding to market, her panniers laden with eggs and butter, exclaims:—

> "Yon raven on the left-hand oak,
> Curse on his ill-betiding croak!
> Bodes me no good!"

And forthwith the old mare stumbles, falls, and bestrews the road

with the contents of her panniers. Then there is the old woman of Wantley :

> " The raven croaked as she sat at her meal,
> And the old woman knew what he said,
> And she turned pale at the raven's tale,
> And sickened and went to bed."

A raven's tongue formed an ingredient in the witches' cauldron when they held their unhallowed interview with Macbeth. The flight of the bird was watched by the Roman augurs in old times, and the triumph or defeat of a General presaged from its character. The raven has always been a bird of note. He is, as you know, frequently mentioned in Scripture. A pair of them were the appointed providers of food to the Prophet Elijah. When, however, Noah sent the raven forth from the ark, he must have been strangely ignorant of the habits of the bird if he expected him to return. The "corbie messenger," as a faithless emissary is called in Scotland, of course took up his abode elsewhere. Amid the ruins of the lately submerged world he found an ample supply of his favourite food, the carcases of drowned beasts and men. To quote Scott again :

> " A blue swollen corse is a dainty meal,"

for the raven, of course.

Besides the hawfinches, the only other rather uncommon birds I can record from personal observation are nut-hatches, a pair of which frequent my lawn, where they pick up the nuts thrown down for the squirrels.

I have seen no records relating to birds in our county papers, excepting those I have already mentioned, worth referring to, unless it be the singular discovery I noticed in a local print, that "birds do not sing in the nesting season" !! I scarcely need say that the exact contrary is the fact. White of Selborne remarks: " Where there is incubation, there is music."

On the 23rd of April Mr. Lewis observed the stonechat, the red-backed shrike, and the black-capped warbler; next to the nightingale perhaps the best songster in our fauna. The swift appeared on the 6th of May, the wryneck on the 22nd of April. Mr. Campbell informed me that woodcocks had lately bred in his neighbourhood. In Aberdeenshire, which I left last month, these birds breed in considerable numbers.

A large flock of peewits was observed by Mr. Lewis near St. Albans in January. These are the birds that lay the much-prized plovers' eggs, sold, I was assured, this spring at 6*d.* to 1*s.* the egg. At the same time they were brought to me both in Wales and in Scotland at a penny apiece. The boys told me that their mothers made puddings of them. The peewit, or green plover, is intermediate between the sandpiper (*Tringa*) and the true plover (*Charadrius*). The golden plover is the type of the latter class; it has three toes only, the sandpipers have four, and the peewit has a rudimentary toe, which takes him out of the category of a true plover, who doubtless regards him with contempt in consequence.

Nightingales were heard this year on the 16th of April. No bird is more easily caught by that pernicious race the birdcatchers than the nightingale, and, though sold at a high price, on none is their cruelty more gratuitously exercised. At least nine out of ten die before they become reconciled to captivity, and even if they live, their lives are very short. The cock bird arrives ten days before the hen, and if caught after her arrival invariably dies. They are becoming more scarce here every year. I used to have a nest or two in my garden, but for many years I have had none: this spring, though, I had a nest. Boys believe that there is always a thorn running through the nest of a nightingale. Of course this is fabulous, but the notion was no doubt at one time prevalent. Shakespeare, in one of his Sonnets, says:—

> "She, poor bird, as all forlorn,
> Leaned her breast until a thorn."

The nightingale, as we all know, sings throughout the night, as well as in the day; but she is far from being the only bird that thus gladdens the night-season. The willow-wren, the sedge-warbler, the corn-crake, and frequently the cuckoo, sing, at least in summer, the night through. In the case of beasts, this habit of utilising the night-season is far more prevalent than with birds. Indeed, the shades of night are to them their "opening day." The poet has told us that "our life is twofold, sleep has its own world." But sleep is not enjoyed by the majority of animals, at least of wild animals, at night, as with us, but during the day. When the "evening shades prevail," the fox and the badger, the otter and the polecat, the whole family of rats and mice, and their enemies the stoats and weasels, steal forth from their lairs and seek their food or their mates. Many aquatic birds, too, wing their way high overhead in the dead of night, terrifying with their unearthly screams the superstitious fishermen, who believe them to emanate from the spirits of the departed seeking their appointed place.

Rooks, during the breeding season, appear hardly to sleep at all. Pass through a rookery at what hour of the night you may, you will always hear a subdued conversation being carried on by the wakeful birds—perhaps mothers dilating on the beauties and merits of their respective offspring. In the way of providing food for their young, rooks are indefatigable; from earliest morn to late in the evening they never cease from the task of feeding their clamorous young—no "eight hours bill" for them! Those restless peewits, too, appear never to sleep. If at any hour of the night you approach a flock roosting on the ground, you will hear a continuous conversation being carried on, in low querulous tones, but never ceasing. Numerous insects, too, moths and beetles especially, as entomologists know, seek repose during the day, and at night are abroad and active. Bees, flies, and butterflies, on the other hand, sleep during the night. Nature in fact allows of no rest or pause in her operations. Whether by night or day the great scheme of creation is carried on, and each bird and beast knows its appointed time, and carries out its appointed functions.

To the sportsman who is also something of a naturalist, the daily habits of the birds he seeks are of great interest, especially in the autumn season, when a complete change is adopted by them in the localities they affect, in their food, and in their mode of life generally. I spent some months this autumn in Scotland, in Kincardineshire, on the banks of that beautiful river, the Dee, when I had ample opportunities of observing these birds.

In August and September the peewits flew about in small flocks; they were comparatively tame, and not infrequently afforded a few shots. In October they joined their forces, and sought their food in vast flocks, numbering, I suppose, many thousands; they were then very shy and kept themselves generally at a safe distance. By the end of October they commenced their southward flight, though many remained behind. No doubt, by this time, detachments have arrived in this neighbourhood. In August, the wild ducks, old and young, frequented the almost impenetrable beds of bulrushes which surround the lakes, out of which, driven by dogs, they gave excellent sport. Later on they adjourned during the daytime to the open water, where, in company with teal, golden eyes, and pochards, they dozed away the time until feeding-hours arrived. They were then very wary, and difficult to approach. As the winter advances they adjourn to the sea and seek their food on the flats and marshes which in many parts fringe the shore. Wood-pigeons, which, singly or in small companies, frequently passed over my head on their way to or from the cornfields, in August and September, like the peewits, congregated in October in vast flocks, and kept far too good a look-out to allow of approach. The object of birds in congregating as so many do in winter, is, no doubt, mutual protection. Without believing the stories of "Sentries" being "posted" by rooks or other birds where great flocks are assembled, we may conclude that there must always be some in a position to detect the approach of danger, and to warn their companions. On the river-bank, up to the middle of September, we had many oyster-catchers, stints, and sandpipers. As autumn advanced, all left us, and sought the sea-shore, where they will remain until pairing time next spring.

Whilst waiting for the wood-pigeons I could not but note the regularity of the time in which they and other birds seek their roosting-places, or their feeding-grounds. First the rooks would come, in long array, the flocks stretching for miles. Until they appeared, no pigeons would arrive; but with the first detachment of the former, the latter might be looked for with certainty, and flying as they do at a considerable height they afforded very pretty shooting. The ducks would succeed the pigeons, seeking their food in the stubbles where the pigeons had been gleaning during the day. Gulls fly home rather earlier than the rooks. The manner of feeding in these birds is essentially different. Pigeons settle in a circle and advance across a field in a semi-circle, each bird, in turn, flying up and settling in advance of the leaders, thereby securing an equally fair chance of picking up food. Ducks

advance across their feeding-ground in a long thin line, each one gobbling up whatever food he comes across. Rooks, when feeding, are comparatively stationary, each bird being engaged on a limited area, digging with his powerful wedge-shaped bill for the mischievous cockchafer grub, or turning over the stones with it in search of the wriggling worm.

But I fear I must have wearied you. My subject has led me far beyond the scope of my original task, which was merely to give an account of my stewardship, as Recorder of the rarer and more interesting birds visiting the county. I can only tender my best thanks to those members of the Society who have favoured me with their observations, and to you, ladies and gentlemen, for the kind attention with which you have listened to my views and comments on them.

XIII.

NOTES ON TINEINA AND OTHER LEPIDOPTERA OBSERVED IN THE NEIGHBOURHOOD OF SANDRIDGE, HERTS.

By A. F. Griffith, M.A.

Read at St. Albans, 18th December, 1890.

Since my former paper on the Lepidoptera of Sandridge was written, in the winter of 1883–84, I have lost no available opportunity of continuing the work then begun. During the year 1884 I was living in London and spent my Saturday afternoons, whenever I could spare them for the purpose, in collecting in the neighbourhood of Sandridge, and succeeded in adding more than thirty species to the list already published, besides raising the number of species of Tineina observed here from about 150 to 230. But since the close of that year my removal into Sussex has made it impossible for me to continue any systematic work in this district. It therefore may be useful to publish my list of Tineina at once, so that it may form, in conjunction with Mr. Durrant's Hitchin lists, published in our 'Transactions' for December, 1885, and those published by Mr. Gibbs in the 'Transactions' for October, 1889, a starting point for a more complete county list. I have also taken the opportunity of supplementing my former list (which included all families of Lepidoptera *except* the Tineina).

To my former list I have three *corrigenda* to make: one arises from a clerical error; another is caused by a recent identification. It has been ascertained that the *Penthina*, which is found widely distributed over England (but nowhere, so far as I can learn, commonly), amongst bugle, is quite distinct from the abundant, but exceedingly local Fen species, *carbonana*, and that it is the *P. ustulana* of Hübner. Of this species I have only met with two examples in the district, one at Symond's Hyde Wood, and one near St. Albans, and it is one of our rarest insects. As to the third of the *corrigenda*, the specimen which I had supposed to be *Ephippiphora gallicolana* is certainly not referable to that species, which is now merged in *obscurana*.

With reference to the *addenda* I may remark that I found a larva of *Orgyia gonostigma* on oak at Bricket Wood in 1884. Two specimens of *Acidalia inornata* occurred at Langley Wood, and a few larvæ of *Eupithecia trisignata* and many of *E. albipunctata* occurred on *Angelica* at Brocket Hall Park and elsewhere. *Lobophora sexalata* appears to be common in one wood at Symond's Hyde, close to which I found the larva of *Chesias spartiata*, while *Thera firmata* occurs on the fir trees in Brocket Hall Park, where I also obtained *Heusimene fimbriana* and *Ocnerostoma piniariella*. I found a specimen of *Miana literosa* at a lamp in the Great Northern Station at St. Albans, while larvæ of *Dianthoecia carpophaga* occur plentifully on bladder-campion on the banks of the Midland Railway, where I have also found the larva of *Calocampa exoleta* on *Heracleum*. *Hydrocampa stagnalis* and *Scoparia pallida* both

occur on the banks of the Lea near Wheathampstead, where *Phlœodes immundana* and *Paedisca sordidana* abound on the alders. Two beautiful red specimens of *Oncocera ahenella* flew into my bedroom at Sandridge one evening, attracted by the light of my lamp. *Stigmonota puncticostana*, *Catoptria Albersana*, and *Lobesia reliquana* occur at Bricket Wood, where the larva of *Peronea tristana* is common, feeding on *Viburnum opulus*, a rather unusual food-plant. Specimens of *Dichrorrhampha flavidorsana* (which is rather a variety of *D. Petiverana* than a distinct species) have occurred near Mackerye End and elsewhere, while *Penthina sellana*, *Argyrolepia sub-Baumanniana*, and *A. Dubrisana* occur on railway-banks with *Eubolia bipunctata*.

Of the Tineina included in my list, several are rare. One of the rarest is undoubtedly *Trifurcula pallidella*, the occurrence of which is recorded in the 'Entomologists' Monthly Magazine,' vol. xxii, pp. 65 and 263. Only one specimen had until then been recorded as British, captured by Mr. Hodgkinson near Preston, but the species has since been taken both in Dorsetshire and Sussex. I took two specimens one evening close to Symond's Hyde Wood, running up grass stems amongst *Genista tinctoria*, which is supposed to be the food-plant of the larva. Another very rare species is *Ornix fagivora*, which was first announced as British from specimens bred by me from larvæ found near Cambridge a few years ago. Of the others, *Dasystoma salicella* is local and not common; I have bred a few from larvæ on black poplar or aspen. *Nematois minimellus* is abundant in one locality near Symond's Hyde, but the females occur far more frequently than the males. In fact until recently I had met with only one male, but one day in 1887 I came across three more close together. This species is fond of settling on thistle stems. *Micropteryx mansuetella* and *Thunbergella* are both local, but common where they occur. *Plutella porrectella* occurs freely in our garden at Sandridge amongst the rocket, under the leaves of which its beautiful white network cocoon can often be found. *Cerostoma sylvella*, *alpella*, and *lucella* are all rare. *Orthotelia sparganella* occurs freely in a little pond close to our garden as well as on the banks of the Lea. *Gelechia cinerella* is rare, one specimen only having occurred. A single specimen of *G. confinis* which I caught on a dry bank at Wheathampstead was identified by Mr. Stainton. One method by which insects are now distributed through new localities was strikingly exemplified by the capture of a *G. dodecella* in a field which had just been planted with Scotch fir seedlings, the nearest Scotch fir trees that I know of being at least a mile distant. *G. bifractella* is abundant in the seed-heads of *Conyza squarrosa* wherever this plant occurs. *Chelaria Hübnerella* I have bred from birch, but I think it must feed on other plants also, as I have taken it far from any birch bushes. *Perittia obscurepunctella* is fairly common amongst honeysuckle, and *Argyresthia ephippella* is abundant amongst the numerous bushes of wild cherry in the woods. *Gracilaria semifascia* appears to be rare, one specimen only

having occurred. *Coleophora currucipennella* has occurred more freely than I have found it elsewhere. *Chauliodus Illigerellus* occurs near Wheathampstead and at Bricket Wood; *Laverna Raschkiella* at Symond's Hyde, where the larva is common in leaves of *Epilobium angustifolium*, though it appears to be rather difficult to rear; *L. subbistrigella* has occurred on the banks of the Midland Railway; *Elachista alpinella* and *poæ* on the banks of the Lea, where *Lithocolletis Stettinella* and *Klemannella* occur rarely and *L. alnifoliella* commonly amongst alder, and *Penthina capræana*, *Spilonota neglectana*, and *Phyllocnistis saligna* amongst sallow and osier. *Lithocolletis corylifoliella* and *emberizæpennella* both appear to be rare, the former feeding not only in hawthorn but also in apple leaves in orchards, and *L. lantanella* is local, as also are *Opostega salaciella* and *Trifurcula immundella*, the former occurring at Bricket Wood and the latter locally amongst broom. Here and there, too, a crab-apple bush may be found with nearly all the leaves mined by *Trifurcula pulverosella*, two larvæ of which frequently make their blotches more or less symmetrically on each side of the mid-rib.

Our Sandridge list now comprises 832 species, while Mr. Durrant's Hitchin lists above referred to comprise 419 species, including fifty-six which neither my brother nor I have met with here. But the whole of his list of Tineina (which includes six species not met with here) constituted an addition to our published County Fauna, my list not having been printed at the time his paper was read. The lists published by Mr. Gibbs (see above) record seven species discovered by him in the neighbourhood of St. Albans which we have not met with, and he also records several Tineina, including *Chimabacche phryganella*, which oddly enough has hitherto entirely escaped me here.

The following table is given to show the number of species hitherto observed by us in this neighbourhood compared with the total number of species included in the British list. For the idea of this table I am indebted to the Purbeck list published by Mr. Bankes in the 'Proceedings of the Dorsetshire Natural History Club,' vol. vi.

Diurni...	29	out of	66	British species.	
Nocturni	43	,, ,,	113	,,	,,
Geometrina	138	,, ,,	289	,,	,,
Pseudobombyces... ...	18	,, ,,	32	,,	,,
Noctuina	122	,, ,,	322	,,	,,
Deltoidæ	4	,, ,,	14	,,	,,
Aventia	1	,, ,,	1	,,	,,
Pyralidina	31	,, ,,	76	,,	,,
Crambites	20	,, ,,	83	,,	,,
Tortricina	150	,, ,,	342	,,	,,
Tineina	266	,, ,,	718	,,	,,
Pterophorina	10	,, ,,	35	,,	,,
Total...	832	,, ,,	2091	,,	,,

I may add that the Purbeck list comprises 879 species, and contains more than mine in each of the above classes except the

Pseudobombyces, of which thirteen species are recorded against my eighteen, the one Aventia, the Tortrices, of which only 136 species are recorded, and the Tineina, which number 245 against my 266. This excess is, however, easily accounted for, not only by the larger number of collectors, and by some of them being residents, but also by the very varied nature of the Isle of Purbeck, including as it does wild heaths (which practically form an outlier of the New Forest), chalk downs, undercliffs, and sand-dunes, a combination which gives unique advantages to any one who can command such happy hunting-grounds. On the other hand, a published list of Lepidoptera observed in West Sussex (another singularly rich district) shows but 661 species, and the only families in this list showing a greater number of species than in mine are the Diurni with thirty-five and the Pterophorina with twelve. But Mr. Fletcher, who published this West Sussex list four or five years ago, has since been steadily working up the district, and could no doubt largely add to it now. The comparison, however, is not an unsatisfactory one, and may serve to stimulate some of our members to greater exertions. In spite of the uniform and comparatively uninteresting character of the district around Sandridge, it is with the greatest regret that I have been compelled to give up my systematic collecting there, just at the time that I was beginning to put the final touches, so to speak, to the work. But I hope that other members of our Society, with better opportunities than mine and more energy than I could bestow upon it, will follow up the subject and make the list of Hertfordshire Lepidoptera worthy of our County and its Natural History Society.

I append the *Corrigenda* and *Addenda* to my former paper, and list of Sandridge Tineina. Also a list of a few additional species observed by myself in other localities in Hertfordshire.

Corrigenda.

For Penthina ochromelana *read* P. ochroleucana.
„ „ carbonana „ „ ustulana.
Dele Ephippiphora gallicolana.

Addenda.

Additional Lepidoptera (other than Tineina) observed in the neighbourhood of Sandridge by myself.

Nocturni.

Orgyia gonostigma.

Geometrina.

Venilia maculata	Acidalia inornata	Scotosia certata
Ennomos tiliaria	Eupithecia trisignata	Eubolia cervinata
Eupisteria heparata	„ albipunctata	„ bipunctaria
Acidalia incanaria	Lobophora sexalata	Chesias spartiata
	Thera firmata	

Noctuina.

Xylophasia rurea	Miana literosa	Cerastis spadicea
Apamea ophiogramma	„ arcuosa	Dianthœcia carpophaga
Miana fasciuncula	Tæniocampa miniosa	Calocampa exoleta

PYRALIDINA.

Hydrocampa stagnalis — Scoparia pallida

CRAMBITES.

Oncocera ahenella

TORTRICINA.

Peronea tristana
Penthina capræana
,, sellana
Spilonota neglectana
Sericoris cespitana
Phoxopteryx diminutana
,, Mitterpacheriana
Phlœodes immundana
Paedisca bilunana
Poedisca occultana
,, sordidana
Ephippiphora nigricostana
,, tetragonana
,, ephippana
Heusimene fimbriana
Carpocapsa grossana
Stigmonota weirana
,, nitidana
Stigmonota puncticostana
,, roseticolana
Dichrorrhampha politana
,, flavidorsana
Catoptria Albersana
Lobesia reliquana
Argyrolepia sub-Baumanniana
Argyrolepia Dubrisana

PTEROPHORINA.

Pterophorus lithodactylus.

List of Tineina observed in the neighbourhood of Sandridge, Hertfordshire, by myself:—

Dasystoma salicella
Exapate gelatella
Diurnea fagella
Talæporia pseudo-bombycella
Fumea intermediella*
Scardia parasitella
cloacella
arcella
Tinea rusticella
tapetzella
pellionella
pallescentella
lappella
biselliella
bistrigella
Lampronia quadripunctella
prælatella
Incurvaria muscalella
Micropteryx calthella
seppella
mansuetella
Thunbergella
purpurella
semipurpurella
Sangiella†
Sparmanella
subpurpurella
Nemophora Swammerdammella
Schwarziella
metataxella
Adela fibulella
Degeerella
viridella
Nematois minimellus
Swammerdammia apicella
spiniella
oxyacanthella
griseocapitella
pyrella
Hyponomeuta plumbellus
padellus
euonymellus
Prays Curtisellus *rusticus* (*var.*)
Plutella cruciferarum
porrectella
Cerostoma sequella
vittella
radiatella
costella
sylvella
alpella
lucella
Harpipteryx xylostella
Theristis caudella
Orthotelia sparganella
Enicostoma lobella
Phibalocera quercana
Depressaria costosa
liturella
assimilella
arenella
subpropinquella
alstrœmeriella
purpurea
hypericella
conterminella
angelicella
applanella
ciliella
granulosella
chærophyllella
heracleana
Psoricoptera gibbosella
Gelechia cinerella
rufescens
populella
nigra
lentiginosella
ericetella
mulinella
sororculella
terrella
politella
Gelechia acuminatella
senectella
confinis
domestica
proximella
notatella
vulgella
luculella
maculea
tricolorella
fraternella
Mouffetella
dodecella
triparella
tenebrella
ligulella
tæniolella
anthyllidella
atrella
bifractella
gemmella
ericinella
Chelaria Hübnerella
Anarsia spartiella
Hypsilophus marginellus
Sophronia parenthesella
Harpella Geoffrella
Dasycera sulphurella
Œcophora flavimaculella

* By this name I intend the species making its case of parallel bits of grass.

† This species has been recently described by Dr. Wood (see 'E. M. M.,' 1891, p. 100), and the name has been added since this paper was read.

Œcophora
lunaris
fuscescens
pseudospretella
Endrosis
fenestrella
Butalis
grandipennis
Glyphipteryx
fuscoviridella
thrasonella
Fischeriella
Perittia
obscurepunctella
Tinagma
sericiellum
Argyresthia
ephippella
nitidella
albistria
semifusca
mendica
retinella
dilectella
curvella
pygmæella
Gœdartella
Brockeella
Ocnerostoma
piniariella
Gracilaria
Swederella
semifascia
elongella
tringipennella
syringella
auroguttella
Coriscium
Brongniardellum
cuculipennellum
Ornix
avellanella
anglicella
betulæ
fagivora
torquilella
guttea

Coleophora
Fabriciella
deauratella
alcyonipennella
paripennella
lixella
albicosta
anatipenella
palliatella
ibipennella
currucipennella
discordella
lineolella
murinipennella
cæspititiella
apicella
argentula
laricella
albitarsella
nigricella
fuscedinella
bicolorella
gryphipennella
viminetella
solitariella
lutipennella
badiipennella
Batrachedra
præangusta
Chauliodus
Illigerellus
Laverna
Raschkiella
epilobiella
ochraceella
subbistrigella
Chrysoclysta
flavicapitella
Asychna
modestella
Chrysocoris
festaliella
Antispila
Pfeifferella
Stephensia
Brunnichella

Elachista
Gleichenella
albifrontella
atricomella
luticomella
poæ
alpinella
cinereopunctella
nigrella
obscurella
zonariella
Megerlella
cerussella
biatomella
triatomea
rufocinerea
cygnipennella
Tischeria
complanella
dodonæa
marginea
Lithocolletis
roboris
lantanella
pomifoliella
corylella
spinicolella
faginella
salicicolella
carpinicolella
ulmifoliella
spinolella
quercifoliella
messaniella
corylifoliella
viminiella
scopariella
alnifoliella
Cramerella
tenella
acerifoliella
emberizæpennella
Nicellii
Stettinella
Klemannella
Schreberella

Lithocolletis
tristrigella
trifasciella
Lyonetia
Clerckella
Phyllocnistis
suffusella
saligna
Cemiostoma
spartifoliella
laburnella
Opostega
salaciella
crepusculella
Bucculatrix
aurimaculella
ulmella
cratægi
Demaryella
frangulella
cristatella
Nepticula
atricapitella
ruficapitella
anomalella
pygmæella
pomella
oxyacanthella
catharticella
septembrella
subbimaculella
argyropeza
trimaculella
floslactella
salicis
microtheriella
betulicola
plagicolella
tityrella
marginicolella
aurella
luteella
Trifurcula
immundella
pallidella
pulverosella

Appendix.

Additional species observed in other localities in Hertfordshire.

Berkhamsted.

Hepialus Velleda.—A specimen was found here at one of the Society's field meetings by Mr. A. E. Gibbs, who pointed it out to me.

Calocampa vetusta.—One specimen was beaten out of a juniper bush in 1884.

Tinea semifulvella.—A specimen of this species was taken at rest on a beech tree.

Royston.

Spilonota lariciana. *Aphelia pratana.*

XIV.

ANNIVERSARY ADDRESS.

THE HORSE.

By the President, the Right Honourable the Earl of Clarendon.

Delivered at the Annual Meeting, 16th February, 1891, at Watford.

Ladies and Gentlemen,—

I cannot claim to myself the credit of having made any material addition to the archives of the Hertfordshire Natural History Society by the Address I delivered last year, nor do I suppose that my aspirations to-night will meet with greater success; but I consider that any one who occupies the important position which I have the honour to hold, namely, that of your President, should strive to the utmost to be practical in his utterances, and, not so much to deliver an address teeming with well-rounded periods, as to impart information to his hearers; and although I do not think it likely that I can add to the storehouse of your knowledge, it may be that you and I look on the subject I am about to consider in different lights and from a different point of view.

I think it is only part of human nature to accept the situation, not to enquire too closely into the why and wherefore, and not fully to recognise the value of our possessions until we are on the eve of losing them or have actually lost them; but it is expedient sometimes to consider what we should be, what we should do, without these possessions,—if we were to be deprived of something which forms part of and enters closely into our daily life.

Let us imagine for one moment the non-existence of the horse. I think that you will agree with me that in that event there are many callings, many trades and professions, which would be irretrievably injured. It is true that what is called the "iron horse" has for the last half-century superseded the necessity for the living animal for many purposes of traffic; but take for instance agriculture, one of the principal occupations of the country. Can it be supposed that the farmer would be able successfully to carry out the various processes of his calling without the aid of the horse? It will be said that oxen are often used for the purpose of ploughing the land, but this is in places where agriculture is carried on under somewhat primitive conditions. Again it might

be urged that in many places the steam plough is to be seen at work, but this is an expensive method of tilling the land, and can only be pursued by the more wealthy and prosperous agriculturists, and the fact remains that for harvesting the grain or other produce of the soil, and for conveying it to the market, the horse is an indispensable necessity. It should be remembered too that horses form part of the stock-in-trade of the agriculturist, and throughout the length and breadth of the country are bred either for sale at country fairs or for disposal to private purchasers. Take again local trade and commerce of all descriptions. It would be impossible to secure that punctuality and despatch in the delivery of goods, which is the pride of our British tradesmen, were it not for the assistance of the horse, to whose strength and speed we owe in the main the arrival of many of the commodities and necessities of life. Take again the case of cavalry and artillery, and the impossibility of substituting any other animal for the horse in those branches of the service. Imagine the Uhlans of the German Army performing their arduous task of scouting on mules, or the English Life Guards entering into action on donkeys! The former with proverbial obstinacy might carry their riders into the very jaws of the foe, while the latter would be unable to sustain the gigantic proportions and colossal weight of our Household Troops. Had these interesting animals, useful enough in their way, taken the place of horses, the many glorious records now inscribed upon the roll of our national fame would be conspicuous by their absence. It has been said that cavalry should be rarely used in battle except to commence an action or to complete a rout, and certainly without the assistance of cavalry a battle would never be properly commenced, nor a rout successfully completed. The lady of fashion in her well-appointed barouche, the disciple of Nimrod on his hunter, the jockey on the high-mettled racehorse, the doctor in his brougham, the man of business in a hack-cab, the butcher boy in his cart, give us hourly and daily proofs of how large a part in our daily life, be it one of business or pleasure, the horse has to bear.

There is an ancient Eastern proverb to the effect that when Allah first formed the world, he tempered the lightning with the west wind and so created the horse. We, who live in a practical age, are well aware that this is but a romance born of Oriental hyperbole, but it is one of those traditions handed down from generation to generation, which at all events serve by way of illus-

tration, and I am inclined to think that in this particular instance it is a flowery, a poetic, but a by no means incorrect imagery of the noble animal which is the subject of my address this evening. The implicit reliance on the guiding hand, the unquestioning obedience to the master will, the docility and fidelity of the beast to man, because he is man, the disregard of fatigue, and the powers of endurance ungrudgingly bestowed, indelibly stamp the horse with that generosity of character which no other of the brute creation can boast, and which both commands the gratitude and calls forth the admiration of those who have relations with the noblest and most generous of God's creatures. It is not too much to say that a reciprocity of affection exists between the horse and its rider, and that the latter owes and in many cases discharges by care and attention a deep debt of gratitude to the animal which has served him well and faithfully it may be for many years. I remember the case of a man who sustained a severe loss by the death of a favourite hunter, and inscribed on a memorial tablet the following epitaph: "To my trusty friend who never failed me in the hour of trial." I think we can all enter into the spirit of the feelings which prompted these words, and sympathize with the lasting regret so touchingly expressed at the loss of a faithful servant.

There is perhaps no nation on earth which enters into closer communion with the horse than the Arab of the desert. The conveyance of his merchandise to and from far distant cities by day and night over the dreary and interminable waste of sand, the tribal disputes, and in these latter days the warfare which has been carried on with more than one European power, renders a close companionship between the man and the beast an absolute necessity; and there are not wanting legends which indeed are founded on fact, that the dusky denizen of the desert shares his affections equally between the woman on whom he has set his heart, and the animal which, it may be, is his more constant companion in peace and war. It is just possible that Zuleika may play him false, but Selim is ever true, and his master knows full well that his affections are not misplaced, and that his faithful servant is ever ready when called upon to offer his services.

Discussions have often been instituted between the comparative intelligence of dogs and horses, rather derogatory to the latter; but it should be remembered that, at all events in this country, where climate and business do not admit of our passing the major

portion of our lives in the open air, and where consequently it is impossible to be always in association with the horse, we do not, we cannot give that animal the great benefit of our company to such an extent as we give it to the smaller beast which can be and often is in continual intercourse with us; but I cannot help thinking that if the horse had equal advantages in that way with the dog, he would exhibit superior intelligence. The dog, it is true, shows speed, sagacity, and strength, but the horse equally possesses these attributes, and in the exercise thereof is compelled moreover to carry or draw a burden, and it is open to doubt if the dog would in the same way as the gallant hunter bear a weight, of course suitable to his powers, with such sagacity and even discrimination over the frequent and formidable obstacles of the hunting-field. An eminent sportsman once said to me: "When my horse and I come across a difficult or dangerous obstacle, I invariably trust to the nobler and better animal of the two." Which of the twain that was, ladies and gentlemen, I leave you to judge. We have yet to learn that the discordant ululations raised by some of the canine species at the sound of dulcet strains are an outward and audible mark of appreciation. I hold rather that it is the unpleasant action of harmony upon an inharmonious subject. But take the horse in some of his many capacities. From time immemorial have we not heard or read that the thrilling blast of the war-clarion sends a tremor of excitement and eagerness throughout the frame of the war-horse, and that he loves the trumpet sound, for he knows that it is the herald of the battle and of the thundering charge in which he is about to take no mean a part? Watch the hunter, and how that gallant beast quivers with pleasure at the sound of the horn which proclaims a fox away, and which is the harbinger of a series of tests on his boldness and endurance. It is possible that his love for such sounds is but born of his instinct of what they are the precursor, and not from intrinsic appreciation of the actual melody; but let us go farther and take the instance of the musical rides which of late years have been such a favourite entertainment in many of our cavalry regiments. Those who have witnessed these displays cannot but feel that the proud bearing and the rhythmic tread of the steeds which take part therein are but an evident token that they possess a keen appreciation of the entrancing strains which accompany their evolutions, and that it is not only unreasoning docility and obedience which guide their nimble feet.

There are instances innumerable of the deep affection entertained by the horse for his master, as also on the other hand of his dislike and terror of those who perhaps have been guilty of only a single act of cruelty towards him. Many years ago a race-horse famed in the annals of the turf, and who has transmitted to his posterity that same power of gaining equine triumphs which he himself possessed, was, on the occasion of a severe race, unnecessarily spurred by his jockey, a past master in the craft of riding, who still lives. Ever after, when the same jockey was about to mount, the horse cowered, winced, and broke into profuse perspiration, although in other hands he was perfectly tractable and showed no signs of fear.

Those who interest themselves in such matters hear a great deal about vice in horses, and doubtless in some of the equine, as of the human race, nature has implanted a vicious habit and character which is ineradicable; but education both of man and beast should be conducted with forbearance, tempered by firmness, and in ninety-nine cases out of a hundred what is termed the vicious horse has been rendered so by acts of brutality or words and gestures of violence during his early training. It is of paramount importance with a high-couraged animal such as the horse, to allay fear and to establish confidence, and his future character and career depend almost entirely upon a judicious blindness to his faults and kindness to his virtues on the part of those to whom his education is entrusted. Who is there amongst us who has not seen what is called a jibbing horse? The "nostrum" applied by way of a cure more often than not is a succession of blows; but generally speaking, one need not look far for the reason, which is not so much obduracy on the part of the horse, but that the burden is too severe for his powers, or that his harness galls him in some way or other, and puts him to unspeakable tortures in the performance of his allotted task. Within the limits of the land there is no Society more deserving of encouragement and support, whose objects are more praiseworthy than those of the Society for the Prevention of Cruelty to Animals, and at their instigation acts of brutality and cruelty receive, as they deserve, condign punishment. Everybody should be a self-constituted champion of humanity, but it is possible to go too far in this direction, and to entertain strained ideas concerning the comfort and discomfort of the brute creation. Diatribes have frequently appeared in the newspapers on the use of the bearing-rein for carriage-horses, which when properly used and lightly

applied is intended only for the purpose of keeping the horse's head in its proper position, and in its use and application has no more the elements of cruelty than the lady's corset or the "masher's" collar.

A love of horses, and indeed a knowledge of their nature and habits, has been a characteristic of many nations of the earth from a remote period. The Medes and Parthians with their flying squadrons of mounted bowmen, the Olympian games of the Greeks, and the hippic contest of the Roman Colosseum furnish positive proof of the inclinations of different nations in this respect. Moreover, even the nomenclature of those early days which has been handed down to men of our own generation attests the prevailing love of the horse, for the name Philip is of Greek origin, and signifies "a lover of the horse," while the hippodamoi were horse-tamers.

Some little while ago a pillar of the turf, himself the soul of honour, and against whom the venomed voice of scandal has never been and never will be raised, said to me: "What an extraordinary thing it is that no one can tell the exact and absolute truth about a horse!" And so it is, from the days of old when the wooden horse containing a phalanx of the besieging host was introduced within the walls of wind-swept Troy, down to the present day, there are countless instances of the noble animal being put to an ignoble use. It would be out of place were I to allude at any length to the frauds which have been practised on the turf concerning which such astounding revelations were made not long since. The sport, it might almost be called the profession of horse-racing, when conducted upon strictly honourable principles, is, apart from its exciting nature, calculated to be productive of beneficial results in perpetuating a more perfect posterity, for the speed, strength, courage, and endurance, which many an equine champion has exhibited, is generally handed down to his progeny; but it is when these gifts of nature are not allowed to be put forth, and when, as sometimes has happened, horses are prevented from doing their best to win a race, that the humiliating reflection comes across one's mind as to which is in reality the nobler animal, the man or the beast, the active or the passive agent of dishonesty. Consider for one moment the case of a handicap, where the weights apportioned to the different competitors are so adjusted that it is supposed to be within the power of any one to prove the winner; and suppose also that a certain horse had been held back purposely in some previous contest; the weight apportioned to that particular horse in the

ensuing race would be such as he could easily carry to victory, and he would thus by dishonest means on the part of either his jockey, owner, or trainer, have acquired a distinct and an undue advantage over the other competitors for the prize. But is this palpable fraud in any way to be laid to the horse's charge? Does it not, rather, raise the blush of shame to the honest cheek that the noble animal should be made the passive instrument of sordid malpractices? And is it not somewhat anomalous that the generous beast should all unwittingly marshal those who have control over him on the road to disgrace and ruin?

There has been during the past twenty-five years a very noticeable decadence of the stamina of the English race-horse, which is nowadays bred with a view to speed rather than endurance. So much so, that while there are a number of prizes of enormous value for races of less than a mile, there are comparatively few for those of over that distance. Experts could easily enumerate the few, the very few English horses which are capable of compassing, say, three miles, at anything like racing pace, and failings in this respect, just in the same way as virtues, are inherited from the sire and the dam. Some people hold, and there is doubtless some truth in the contention, that two-year-old racing has a great deal to do with the falling off in what is called "staying" power, for although the distance horses of two years old are called upon to cover is never more than, and more often not as much as, three-quarters of a mile, and that too with feather-weights on their backs, yet it must be remembered that these races are run at topmost speed, and that the strain is such as often to leave indelible marks upon an undeveloped constitution and an immature frame. It may of course be said that the world might go round without racing and race-horses, but it is from their loins that most of our hunters, carriage-horses, and hacks have sprung, and unless these latter could trace their descent from some thoroughbred ancestor, they would find but little favour in our eyes; for they would be not only destitute of that courage which "*pur sang*" only gives, but they would also be devoid of that make and shape without which it would be impossible for them to perform their tasks with ease to themselves or with comfort and safety to their masters. At Wentworth, Lord Fitzwilliam's seat in Yorkshire, exists perhaps the *chef-d'œuvre* of that king of animal-painters—Stubbs. It is a life-size portrait of a horse; and the great master was evidently of opinion that his subject was so peerless in form, so utterly perfect in proportion, that it would

speak for itself, for there is nothing depicted on the canvas save the horse itself in all its beauty without the accessories of landscape, background, or sky. And there is more in this matter of make and shape than would at first sight appear to be the case. The horse with a thick, short neck is likely to make a puller unless he is very carefully handled, mouthed, and bitted during the time of his early training, while animals with long ewe necks are invariably predisposed to unsoundness in the wind. Again, unless there be sloping shoulders well let into the body, they do not possess that freedom of action, that long swinging stride which is essential to speed as well as to the rider's comfort. If the shoulders be straight, the forelegs do not stand or move in such a manner as to secure a properly-balanced animal. While all the four legs should be conspicuous for muscular arms and thighs, the cannon-bone, that is, the bone from the knee to the fetlock joint, should not be back from the knee, but should be short, flat, and sinewy; the pasterns should be somewhat long and sloping in order to give play to the foot, which should be of sufficient size to bear the weight of the horse's body; and the barrel should be round and well ribbed up.

It will, I hope, be understood that in the remarks I have ventured to make concerning the horse, I have alluded only to the typical specimens of the race, for there is as much difference between Goliath and Lilliput, as between the magnificent, shapely, pure-bred animal who "snorts in his mettle and his pride," and the jaded Rosinante who can scarce sustain the shafts of a four-wheeled cab upon its weary broken-down limbs and body. And yet what a touching romance is often connected with this latter! There was a time, may be, and not so very long since, when the now emaciated frame was clothed with muscular flesh and glossy coat; when the proud and indomitable spirit, now crushed by hard usage and quelled by scanty sustenance, knew no defeat on the turf, no rival in the hunting-field; when the neck, now bent and bowed in submission to a relentless fate, was carried haughty and erect, proud, peradventure, to receive the loving caress of a tender hand as the guerdon of triumphs won by flood and field! Well is it for such that the senses they have are steeped in Lethe, and that they are incapable of recollecting the light of other days and the glories of the past! "Sorrow's crown of sorrow is remembering happier things." Could they then bear in mind the gallant deeds they once achieved, or the lavish praises bestowed on their past labours, a thousand-fold would be added to the grief and privation

which is their present lot! But should not this reflection be an additional incentive to man to treat the dumb servant who has ministered to his pleasures or to his wants with all the more loving care and grateful consideration?

There is another matter which does not invariably receive the attention which it merits, and that is the proper disposition of saddlery and appointments. In this respect, however, exception must be made regarding horses used for cavalry purposes, for in their case rules are laid down for the proper place and method of fitting for each single article of the horse's gear; for instance, the saddle is to be placed on the middle of the horse's back, the front of it about the breadth of the hand behind the play of the shoulder; the bit should fit with the mouthpiece one inch above the lower tusk of a horse, and two inches above the corner tooth of a mare. These regulations ensure the saddle being carried and the bit worn in such a manner as to cause the least possible inconvenience or discomfort to the horse, and to obviate the probability of either a sore mouth or a galled back. A rigid observance of these rules, especially during warfare, is, apart from humanity, absolutely essential, for if the horse has a sore mouth or back, he cannot be bitted or saddled, and his rider is thus rendered *hors-de-combat.*

In the hurry and turmoil of the hunting-field many accidents occur which it is impossible to foresee, prevent, and in some cases to remedy. Some few years ago a curious misadventure happened to myself. I was out hunting on a favourite horse, and, whilst going through a gate, came into too close proximity to the horse of a fair equestrian in front of me. Her steed resented the supposed insult, and lashed out, just catching my horse underneath the jaw, inflicting a scarcely perceptible wound, and one which at first sight appeared to be of a trivial nature. Every care was taken of the patient, and I sent him up for a little while to the Veterinary College in London, where all that surgical skill could do was done; but the jaw-bone had evidently been seriously injured, and so great were the sufferings of the wretched animal that I ordered him to be destroyed and the jaw-bone to be preserved and given to me. [This was handed round for inspection.] It will easily be imagined what unspeakable agony this process of ossification caused, and how that the only true kindness was to put an end to a life of torture.

It would be tedious as well as unnecessary to review in detail the numberless ills that horseflesh is heir to. Some of these, such

as splints, sidebones, ringbones, curbs, and spavins, are osseous excrescences and may sometimes be removed by proper treatment; but one of the most prevalent diseases in England is that of roaring or unsoundness in the wind, and no remedy, however drastic, can combat or remove this evil, which renders the horse comparatively valueless, and almost always prevents anything like sustained effort on his part. The disease is in the main attributable to the dampness of our climate and the prejudicial effect it has on the horse's respiratory organs. Horses of other countries which can boast of a drier and more genial atmosphere are but rarely affected in this way, and it has been even said that if a horse touched in the wind be sent to the Argentine Republic, a cure may be effected; but experience tells us that this particular malady is so organic and so deep-seated that there exists no successful nostrum for its cure. In our relations with the horse, health should be a great consideration, and therefore to him in his hygienic character much is due from the dyspeptic gourmand with jaded appetite and impaired digestion, as well as from the fair *débutante* eager to dispel the effects of midnight revels by the morning gallop. Once mounted on the high-mettled steed, with the keen fresh air blowing in their faces, where are all the woes and grievances of life, real and imaginary? Gone, vanished to the four winds of heaven—those very winds which give in return a highly advantageous bargain—the benefit of a quickened appetite, and the roseate hues of restored health! But in thinking of our own, the horse's health should likewise be studied with due diligence, and taking one consideration with another, the rearing of a foal up to the days of its maturity is as difficult a matter as that of an infant. The fact is that the horse, as used in this and other civilized countries, passes an artificial life. In his free and natural condition he roams over the boundless prairie, inhaling the fresh, pure, untainted air, and having for his food only the succulent herbage of the plain. Here, under man's domination and the thraldom of civilization, he is confined within the four walls of a narrow stable, and fed for the most part upon corn, which although of a strengthening is likewise of a heating nature. Under these circumstances he is liable to chills and the baneful results which arise therefrom. There is nothing, for ostensible reasons, so injurious to horses' health as hot stables, and every horse after his day's work is finished should be carefully wisped with straw over the body, and his legs and feet, especially, should be washed and dried before he is done up for

the night. In the spring and summer he should always be given tares or fresh young grasses, which being of a cooling nature counteract the heating properties of corn.

Some of us are even slaves to our pets, and although there is perhaps nothing elevating in affection for soulless animals, and love for the brute creation may be carried too far, it is, notwithstanding, an indication of character, and one can never regard the care man bestows upon, and the protection he affords to, his dumb favourites, without recognising the truth of the old adage that it is "the merciful man that is merciful to his beast," and without believing that this tender feeling, this "milk of human kindness," as it were, is extended in a greater degree to his human fellow-creatures. It was once my fate to be riding alongside of a brother sportsman when he broke his horse's back in landing over a small obstacle. We passed the spot the next day. Was it womanly or weak that the bereaved Nimrod should gaze at the body of his favourite, now stiff and stark in death, through a mist of tears? Was it not rather a sign of a warm, a grateful, and a sympathetic disposition, which, if displayed towards an animal, is more than likely to be exhibited towards mankind?

I am well aware that my Address has been diffuse, and perhaps inconsequent; but it is difficult, within the narrow limits of a brief discourse, to treat the subject I have chosen save after a generalising manner. I do not presume so far as to say that I have made my point as to the necessity for the existence of the horse, and it may be that the sentiments I have expressed are but the outcome of "horse on the brain"; but man is apt to take himself as a standard whereby to judge of others, and owing as I do much of the health and happiness I enjoy to the horse, I am not unnaturally grateful to him for being the means of providing these priceless boons; and I doubt not but that many of my countrymen and countrywomen would be, as I myself am to-night, glad to place that gratitude on record.

XV.

REPORT ON PHENOLOGICAL PHENOMENA OBSERVED IN HERTFORDSHIRE DURING THE YEARS 1889 AND 1890.

By John Hopkinson, F.L.S., F.G.S., etc., President.

Read at Watford, 16th March, 1891.

The Phenological Stations from which returns have been received for the years 1889 and 1890 are the same as those for which records of the dates of flowering of plants were given in the principal table for the years 1887 and 1888, the two stations, Ware and Odsey, for which there was a supplementary table in the previous report, disappearing from our list. Our present phenological stations are therefore as follows:—

River-basin.	Station.	N. Lat.	W. Long.	Observer.
Colne	St. Albans	51 45	0 20	Mrs. J. Hopkinson.
	Harpenden	51 48	0 21	Mr. J. J. Willis.
Lea	Hertford	51 48	0 5	Mr. W. Graveson.
Ivel	Hitchin	51 57	0 16	Natural Hist. Club.

Although details of the observations of Insects and Birds no longer appear elsewhere, in order to economise space the plan adopted in previous reports is followed in this one, the earliest observations only being recorded.

Earliest Dates of Observations of Insects, Birds, etc., in 1889 and 1890, with the mean date for 1876-88.

No.	Phenomena.	1889.	1890.	Mean.
	Insects.			
84	*Apis mellifica* (honey-bee) ap.	Jan. 26	Jan. 19	Jan. 27
85	*Vespa vulgaris* (common wasp) ap.	May 6	Mar. 16	Apl. 7
86	*Pieris Brassicæ* (large white butterfly) ap.	Apl. 11	Mar. 28	Apl. 9
87	*P. Rapæ* (small white butterfly) ap.	May 5	Apl. 5	Mar. 29
88	*Anthocaris cardamines* (orange-tip) ap.	May 22	May 25	May 5
89	*Epinephele Janira* (meadow-brown) ap.	Apl. 26	Apl. 29	May 22
	Birds.			
91	*Syrnium Aluco* (tawny owl) hoots	Mar. 31	.....	Apl. 5
93	*Turdus musicus* (song-thrush) sg.	Jan. 10	Jan. 16	Jan. 12
95	*Daulias Luscinia* (nightingale) sg.	Apl. 23	Apl. 16	Apl. 14
99	*Alauda arvensis* (sky-lark) sg.	Jan. 26	Jan. 12	Jan. 17
101	*Corvus frugilegus* (rook) builds	Mar. 2	Mar. 4	Feb. 23
102	*Cuculus canorus* (cuckoo) calls	Apl. 22	Apl. 4	Apl. 12
103	*Hirundo rustica* (swallow) arr.	Apl. 23	Apl. 14	Apl. 11
104	*Chelidon urbica* (house-martin) arr.	Apl. 30	May 11	Apl. 20
108	*Turtur communis* (turtle-dove) coos	May 4	.....	May 4
111	*Crex pratensis* (corncrake) arr.	Apl. 27	.....	Apl. 25
	Amphibian.			
112	*Rana temporaria* (common frog) spawns	Mar. 24	Mar. 12	Mar. 13

ap.—first appears. arr.—arrives. sg.—song commences.

Dates of Flowering of Plants observed in 1889 and 1890, with the Mean Date for 1876-88.

No.	Species.	1889.				1890.				Mean. 1876-88.
		St. Albans.	Harpenden.	Hertford.	Hitchin.	St. Albans.	Harpenden.	Hertford.	Hitchin.	
1.	*Anemone nemorosa* (wood anemone)	Mar. 31	Mar. 29	Mar. 31	Mar. 15	Mar. 30	Mar. 16	Mar. 16	Mar. 14	Mar. 16
56.	*Ligustrum vulgare* (privet)	.....	June 27	June 23	July 8	.....	.....	June 22	June 17	June 19
57.	*Calystegia sepium* (greater bindweed)	July 7	July 15	July 4	July 1	.....	.....	July 20	July 11	July 6
58.	*Symphytum officinale* (comfrey)	May 14	.....	May 13	.....	May 10	.....	May 11	.....	May 10
59.	*Pedicularis silvatica* (red rattle)	May 19	.....	.....	.....	May 17	.....	.....	.....	May 16
60.	*Veronica Chamædrys* (speedwell)	Apl. 27	Apl. 28	Apl. 20	Apl. 19	Apl. 19	Apl. 30	Apl. 20	Apl. 26	Apl. 26
61.	*Mentha hirsuta* (water mint)	.....	.....	July 31	July 20	.....	.....	July 20	Aug. 18	July 28
62.	*Thymus Serpyllum* (wild thyme)	.....	.....	June 23	June 8	.....	.....	June 29	June 11	June 10
63.	*Prunella vulgaris* (self-heal)	.....	June 15	June 16	June 19	.....	.....	June 13	June 21	June 19
64.	*Glechoma hederacea* (ground-ivy)	Apl. 14	Apl. 17	Apl. 7	Apl. 6	Apl. 4	Apl. 2	Mar. 28	Mar. 21	Mar. 28
65.	*Galeopsis tetrahit* (hemp-nettle)	.....	.....	June 22	.....	.....	.....	June 24	.....	June 20
66.	*Stachys silvatica* (hedge woundwort)	June 14	June 15	June 6	June 13	June 15	.....	June 15	June 13	June 8
67.	*Ajuga reptans* (bugle)	.....	May 12	May 9	May 10	.....	May 7	May 4	May 13	May 5
68.	*Primula officinalis* (cowslip)	Mar. 31	Mar. 29	Apl. 7	Apl. 3	Apl. 2	Apl. 3	Apl. 4	Mar. 28	Mar. 22
69.	*Plantago lanceolata* (ribwort plantain)	May 3	May 6	May 5	Apl. 30	Apl. 27	Apl. 30	Apl. 20	Apl. 24	Apl. 22
70.	*Mercurialis perennis* (dog's mercury)	Feb. 12	Feb. 11	.....	Mar. 15	Mar. 8	Mar. 14	.....	.....	Feb. 24
71.	*Ulmus montana* (wych elm)	.....	Mar. 24	Apl. 19	Mar. 22	....	Feb. 14	Feb. 16	Feb. 4	Mar. 5
72.	*Salix Caprea* (great sallow)	Mar. 27	Mar. 30	Mar. 31	Mar. 22	Mar. 8	Feb. 28	Mar. 16	Mar. 16	Mar. 12
73.	*Fagus silvatica* (beech)	.....	.....	.....	.....	.....	.....	May 11	May 7	May 13
74.	*Corylus Avellana* (hazel)	Feb. 14	Feb. 8	Feb. 3	Jan. 29	.....	Jan. 14	Jan. 12	Jan. 19	Jan. 26
75.	*Orchis maculata* (spotted orchis)	.....	June 6	May 30	June 2	.....	.....	May 31	June 27	June 5
76.	*Iris Pseudacorus* (yellow iris)	.....	.....	June 3	June 6	.....	....	May 29	June 26	June 5
77.	*Narcissus Pseudo-narcissus* (daffodil)	Mar. 21	Mar. 30	Apl. 4	Mar. 30	Mar. 17	Mar. 18	Mar. 30	Mar. 16	Mar. 10
78.	*Galanthus nivalis* (snowdrop)	Jan. 30	Feb. 3	Feb. 3	Jan. 22	Jan. 25	Jan. 28	Feb. 16	Jan. 12	Jan. 24
79.	*Scilla nutans* (blue-bell)	May 4	Apl. 26	Apl. 25	Apl. 26	Apl. 14	Apl. 4	Apl. 6	Apl. 3	Apl. 17

Dates of Flowering of Plants observed in 1889 and 1890, with the Mean Date for 1876-88.

No.	Species.	1889.				1890.				Mean. 1876-88.
		St. Albans.	Harpenden.	Hertford.	Hitchin.	St. Albans.	Harpenden.	Hertford.	Hitchin.	
1.	*Anemone nemorosa* (wood anemone)	Mar. 31	Mar. 29	Mar. 31	Mar. 15	Mar. 30	Mar. 16	Mar. 16	Mar. 14	Mar. 16
2.	*Ficaria verna* (lesser celandiue)	Feb. 18	Mar. 28	.....	Mar. 15	Feb. 25	May 16	.....	Feb. 10	Feb. 24
3.	*Ranunculus acris* (upright crowfoot)	.....	May 6	Apl. 19	Apl. 19	.....	Apl. 15	Apl. 20	May 13	Apl. 24
4.	*Caltha palustris* (marsh marigold)	Apl. 18	Apl. 27	May 31	Apl. 1	Apl. 13	Apl. 20	Apl. 6	Mar. 16	Mar. 27
5.	*Papaver Rhœas* (red poppy)	Juue 5	Juue 6	Juue 6	May 13	Juue 1	June 7	June 2	May 28	May 30
6.	*Nasturtium officinale* (water-cress)	.....	.....	May 30	Juue 19	.....	.....	May 29	June 26	June 2
7.	*Cardamine pratensis* (cuckoo-flower)	Apl. 21	Apl. 28	Apl. 18	Apl. 21	Apl. 19	Apl. 27	Apl. 6	Apl. 21	Apl. 14
8.	*Alliaria officinalis* (garlic-mustard)	.....	May 5	Apl. 14	Apl. 21	.....	Apl. 30	Apl. 4	Apl. 20	Apl. 19
9.	*Erophila vulgaris* (whitlow grass)	.....	Apl. 26	Mar. 31	Mar. 4	.....	Mar. 28	Mar. 14	Mar. 10	Mar. 10
10.	*Viola odorata* (sweet violet)	Mar. 21	Mar. 24	Mar. 17	.....	.....	Mar. 15	Mar. 16	.....	Feb. 19
11.	*Polygala vulgaris* (milkwort)	.....	.....	May 9	May 21	May 19	.....	May 22	May 22	May 11
12.	*Lychnis Flos-cuculi* (ragged Robin)	.....	Juue 8	Juue 1	May 18	.....	June 8	Mar. 28	May 22	May 26
13.	*Stellaria Holostea* (greater stitchwort)	Apl. 12	Apl. 23	Apl. 19	Apl. 25	Apl. 14	Apl. 15	Mar. 30	Apl. 16	Apl. 7
14.	*Malva silvestris* (common mallow)	Juue 8	.....	June 6	May 24	.....	.....	June 5	June 11	June 8
15.	*Hypericum quadratum* (square St. J. w.)	.....	.....	July 14	July 9	.....	.....	July 16	.....	July 9
16.	*H. pulchrum* (upright St. John's wort)	.....	.....	July 2	Juue 30	.....	.....	July 6	.....	June 30
17.	*Geranium Robertianum* (herb Robert)	May 12	May 12	May 9	.....	May 1	May 23	May 8	Apl. 24	Apl. 29
18.	*Euonymus europæus* (spindle-tree)	Juue 1	.....	May 23	.....	Juue 1	.....	June 1	May 29	June 2
19.	*Acer Pseudo-platanus* (sycamore)	May 5	.....	May 16	May 7	Apl. 19	May 6	Apl. 20	Apl. 25	May 4
20.	*Æsculus Hippocastanum* (h. chestnut)	May 7	May 10	May 7	May 12	May 7	May 12	May 4	May 6	May 10
21.	*Cytisus Laburnum* (laburnum)	May 13	May 20	May 16	Mar. 14	May 8	May 6	May 10	May 10	May 19
22.	*Trifolium repens* (Dutch clover)	.....	Juue 5	May 23	May 24	.....	.....	May 6	May 17	May 19
23.	*Lotus corniculatus* (bird's foot trefoil)	.....	Juue 5	May 19	.....	May 19	May 30	May 16	May 17	May 22
24.	*Vicia Cracca* (tufted vetch)	June 15	.....	June 6	June 16	.....	.....	.....	Juue 28	June 23
25.	*V. sepium* (bush vetch)	.....	May 18	May 9	May 16	May 1	May 26	.....	.....	Apl. 30
26.	*Lathyrus pratensis* (meadow vetchling)	.....	Juue 6	Juue 3	Juue 8	.....	.....	June 15	June 7	Juue 4
27.	*Prunus spinosa* (blackthorn)	Apl. 16	Apl. 28	Apl. 19	Apl. 20	Apl. 13	Apl. 3	Mar. 23	Mar. 28	Mar. 29
28.	*Spiræa Ulmaria* (meadow sweet)	.....	.....	June 13	Juue 25	.....	.....	June 19	June 20	Juue 17
29.	*Potentilla anserina* (silver-weed)	.....	.....	May 23	May 21	.....	June 1	May 16	May 16	May 17
30.	*Rosa canina* (dog-rose)	June 6	Juue 5	June 6	May 30	June 1	June 3	June 5	May 26	June 4
31.	*Sorbus Aucuparia* (mountain ash)	May 25	May 26	May 30	May 21	May 10	May 23	May 22	May 15	May 22
32.	*Cratægus Oxyacantha* (hawthorn)	May 14	May 18	May 12	May 7	May 11	May 17	May 8	Apl. 30	May 15
33.	*Epilobium hirsutum* (hairy willow-hb)	.....	.....	June 27	July 3	.....	.....	July 13	July 12	July 7
34.	*E. montanum* (broad willow-herb)	.....	Juue 13	June 6	June 7	June 15	June 22	June 1	June 12	June 11
35.	*Angelica silvestris* (wild angelica)	.....	.....	June 30	July 31	.....	.....	July 27	Aug. 9	Aug. 1
36.	*Daucus Carota* (wild carrot)	.....	.....	July 2	Juue 29	.....	.....	July 9	July 12	July 3
37.	*Hedera Helix* (ivy)	Sept. 22	.....	Sept. 15	Sept. 20	.....	.....	Oct. 5	Oct. 12	Sept. 24
38.	*Cornus sanguinea* (dog-wood)	.....	June 23	June 16	June 13	.....	.....	June 15	June 17	June 18
39.	*Syringa vulgaris* (lilac)	.....	May 12	May 9	May 7	May 6	May 8	May 4	May 3	May 10
40.	*Galium Aparine* (cleavers)	.....	May 30	May 19	May 8	.....	May 24	May 11	May 7	May 16
41.	*G. verum* (yellow bedstraw)	.....	Juue 26	June 23	Juue 29	.....	.....	June 20	Juue 30	June 28
42.	*Dipsacus silvestris* (wild teasel)	.....	.....	July 30	Aug. 22	.....	.....	July 27	Aug. 9	July 28
43.	*Succisa pratensis* (devil's bit)	.....	.....	June 23	Juue 19	.....	.....	June 29	Aug. 13	July 27
44.	*Petasites vulgaris* (butter-burr)	.....	....	Mar. 31	.....	May 17	.....	Mar. 14	.....	Mar. 22
45.	*Tussilago Farfara* (coltsfoot)	Feb. 18	Feb. 17	Feb. 17	Feb. 18	.....	Mar. 19	Feb. 12	.....	Feb. 24
46.	*Achillea Millefolium* (milfoil)	.....	June 24	June 20	June 26	June 22	.....	June 15	June 28	June 21
47.	*Leucanthemum vulgare* (ox-eye)	May 25	May 23	May 21	May 18	May 19	May 18	May 21	May 24	May 19
48.	*Artemisia vulgaris* (mugwort)	.....	.....	July 25	July 24	.....	.....	July 29	Aug. 8	July 30
49.	*Senecio Jacobæa* (ragwort)	.....	.....	June 30	June 25	.....	.....	June 22	.....	June 29
50.	*Centaurea nigra* (black knapweed)	June 15	Juue 12	June 20	July 13	June 22	.....	June 25	June 28	June 19
51.	*Cirsium lanceolatum* (spear thistle)	.....	.....	June 27	July 13	June 29	.....	July 13	July 19	June 21
52.	*C. arvense* (field thistle)	.....	July 3	June 23	Juue 27	.....	.....	June 26	June 26	June 22
53.	*Sonchus arvensis* (corn sow-thistle)	.....	July 3	July 14	July 13	.....	.....	July 17	July 14	July 8
54.	*Hieracium Pilosella* (mouse-ear)	.....	June 1	May 19	June 16	.....	June 8	May 8	June 7	Mar. 17
55.	*Campanula rotundifolia* (bair-bell)	.....	July 2	July 2	July 2	July 7	.....	July 9	July 4	July 5
56.	*Ligustrum vulgare* (privet)	.....	June 27	June 23	July 8	.....	.....	Juue 22	June 17	June 19
57.	*Calystegia sepium* (greater bindweed)	July 7	July 15	July 4	July 1	.....	.....	July 20	July 11	July 6
58.	*Symphytum officinale* (comfrey)	May 14	.....	May 13	.....	May 10	.....	May 11	.....	May 10
59.	*Pedicularis silvatica* (red rattle)	May 19	.....	.....	.....	May 17	.....	.....	.....	May 16
60.	*Veronica Chamædrys* (speedwell)	Apl. 27	Apl. 28	Apl. 20	Apl. 19	Apl. 19	Apl. 30	Apl. 20	Apl. 26	Apl. 26
61.	*Mentha hirsuta* (water mint)	.....	.....	July 31	July 20	.....	.....	July 20	Aug. 18	July 28
62.	*Thymus Serpyllum* (wild thyme)	.....	.....	June 23	Juue 8	.....	.....	June 29	June 11	June 10
63.	*Prunella vulgaris* (self-heal)	.....	June 15	Juue 16	Juue 19	.....	.....	June 13	June 21	June 19
64.	*Glechoma hederacea* (ground-ivy)	Apl. 14	Apl. 17	Apl. 7	Apl. 6	Apl. 4	Apl. 2	Mar. 28	Mar. 21	Mar. 28
65.	*Galeopsis tetrahit* (hemp-nettle)	.....	.....	June 22	.....	.....	.....	June 24	.....	June 20
66.	*Stachys silvatica* (hedge woundwort)	June 14	June 15	Juue 6	June 13	Juue 15	.....	June 15	June 13	June 8
67.	*Ajuga reptans* (bugle)	.....	May 12	May 9	May 10	.....	May 7	May 4	May 13	May 5
68.	*Primula officinalis* (cowslip)	Mar. 31	Mar. 29	Apl. 7	Apl. 3	Apl. 2	Apl. 3	Apl. 4	Mar. 28	Mar. 22
69.	*Plantago lanceolata* (ribwort plantain)	May 3	May 6	May 5	Apl. 30	Apl. 27	Apl. 30	Apl. 20	Apl. 24	Apl. 22
70.	*Mercurialis perennis* (dog's mercury)	Feb. 12	Feb. 11	.....	Mar. 15	Mar. 8	Mar. 14	.....	.....	Feb. 24
71.	*Ulmus montana* (wych elm)	.....	Mar. 24	Apl. 19	Mar. 22	....	Feb. 14	Feb. 16	Feb. 4	Mar. 5
72.	*Salix Caprea* (great sallow)	Mar. 27	Mar. 30	Mar. 31	Mar. 22	Mar. 8	Feb. 28	Mar. 16	Mar. 16	Mar. 12
73.	*Fagus silvatica* (beech)	.....	.....	.....	.....	.....	.....	May 11	May 7	May 13
74.	*Corylus Avellana* (hazel)	Feb. 14	Feb. 8	Feb. 3	Jan. 29	.....	Jan. 14	Jan. 12	Jan. 19	Jan. 26
75.	*Orchis maculata* (spotted orchis)	.....	Juue 6	May 30	June 2	.....	.....	May 31	June 27	June 5
76.	*Iris Pseudacorus* (yellow iris)	.....	.....	June 3	June 6	.....	....	May 29	June 26	June 5
77.	*Narcissus Pseudo-narcissus* (daffodil)	Mar. 21	Mar. 30	Apl. 4	Mar. 30	Mar. 17	Mar. 18	Mar 30	Mar. 16	Mar. 10
78.	*Galanthus nivalis* (snowdrop)	Jan. 30	Feb. 3	Feb. 3	Jan. 22	Jan. 25	Jan. 28	Feb. 16	Jan. 12	Jan. 24
79.	*Scilla nutans* (blue-bell)	May 4	Apl. 26	Apl. 25	Apl. 26	Apl. 14	Apl. 4	Apl. 6	Apl. 3	Apl. 17

In the following remarks on the phenology of the two years, I refer, as before, to the dates of flowering of the 60 species of plants, most of which have been observed every year during our period, which now embraces fifteen years, while none have been overlooked for more than two years. The ivy, which is also mentioned, is not one of these. Every plant on the list of the Royal Meteorological Society was observed in 1889 and 1890.

The number of species to be observed has now been greatly reduced, and it is hoped that one result of this will be a large accession of observers. The new list is given by Mr. Mawley in the following paper.

Phenology of 1889.

The year 1889 was on the whole an average year. Although vegetation was backward in the spring, it was forward in the summer, and on the average half a day (0·6) early. Of the 60 selected species, 25 came into flower later than the mean of 1876-88, 34 earlier, and 1 on the same day as the mean.

Of the 30 species which come into flower before the middle of May (our spring flowers), 20 appeared after the mean date and 10 before it; and of the 30 which come into flower after the middle of May (our summer flowers), 5 appeared after the mean date, 24 before it, and 1 on the same day as the mean. The spring flowers were on the average four days (3·9) late, and the summer flowers five days (5·1) early.

Dividing the period of observation into three, the average date of the first 20 species flowering up to the third week in April is 5·3 days late; of the next 20 flowering up to the end of May, 1·2 early; and of the last 20 flowering up to the end of July, 5·9 early. Thus vegetation was backward only in the early spring, rather forward towards the end of spring, and half a day more forward in summer than it was backward in spring.

Taking each 10 species in succession, the second group is seen to be very late and the last very early, the third shows very little deviation from the mean, while the fourth and fifth are about as early as the first is late. The average for February is 3·3 days late; for March 7·3 late; for April 1·1 late; for May 3·5 days early; for June 3·3 early; and for July 8·5 early.

The first four months in the year were cold, February especially so, thus accounting for the lateness of vegetation in March. May and June were warm, the temperature in May being almost as much above the average as it was below the average in February; thus, although at the end of April, as our Harpenden observer says, the season was backward, in May "the wild flowers had more than retrieved their backward condition." The warm weather in May does not, however, seem to have produced its full effect on vegetation until about the middle of June. At Harpenden "the first wheat-ear was observed fully out of its sheath on the 13th of June."

Although July, August, and September were cold and humid, the ivy came into flower rather earlier than usual.

Phenology of 1890.

In the year 1890 vegetation was forward throughout the whole period of observation, January to July, but not to any great extent, the mean being only 3·3 days early. Of the 60 selected species 20 came into flower later than the mean of 1876-88, 37 earlier, and 3 on the same day as the mean.

Of the 30 spring flowers 7 appeared after the mean date, 20 before it, and 3 on the same day as the mean; and of the 30 summer flowers 13 appeared after the mean date and 17 before it. The spring flowers were on the average 4·3 days early, and the summer flowers 2·3 days early.

The average date of flowering of the first 20 species is 5·4 days early; of the next 20, 3·7 days; and of the last 20, not quite one day (0·8). Thus vegetation was most forward in the early spring, rather less forward towards the end of spring, and very little forward in the summer.

Of each group of 10 species every one is early; the second being the earliest, and the fourth and first following closely in succession; while the fifth is about the mean, and the third and sixth are only slightly forward. The average for February is 4·9 days early; for March 6·0 days; for April 2·2; for May 5·3; for June 0·2; and for July 1·4.

January was very warm, February very cold, but this seems to have had no retarding effect upon vegetation. March and May were rather warm, April and June rather cold, and in July the temperature was considerably below the average. Although our wild flowers were early throughout the spring and summer, the effect of the cold weather in April, June, and July is apparent in their comparative backwardness in those months. In January, Mr. Willis says, "the mildness of the weather caused many plants, especially the primrose, to produce blooms in great profusion; in February "the general appearance of the winter crops was satisfactory;" in March, "although the season was early, the occasional cold nights sufficed to prevent that inopportune and over-hasty development of vegetable growth which comes of mild weather without a break;" in May "the weather for the most part was pleasant and summer-like, although the winds occasionally were harsh and strong;" and in July the weather was less disastrous to the grain crops than in either of the three previous years, "although much of the grain was sadly 'lodged' and many green stems were growing through, greatly interfering with satisfactory ripening, and also with the operation of cutting."

July, August, and September had practically the same temperature, September being about as much warmer than usual as July and August were colder; nevertheless the last species on our list, the ivy, was late in coming into flower, apparently showing that it was influenced by the cold weather which prevailed at least six weeks before its flowers appeared.

XVI.

A SIMPLE METHOD OF TAKING PHENOLOGICAL OBSERVATIONS.

By Edward Mawley, F.R.Met.Soc., F.R.H.S.,

Phenological Recorder to the Royal Meteorological Society.

Read at Watford, 16th March, 1891.

The subject on which I wish to offer a few remarks has unfortunately a very high-sounding title, considering what a very simple one it really is. It is known to a select few as Phenology, or the science of appearances. But as there is scarcely a dictionary of the English language which mentions this word at all, it is not surprising that we seldom come across any one who has ever heard of it, much less understood its meaning. Yet most people living away from large towns are in the habit of noticing the first appearance of wild flowers, birds, insects, etc., while it is truly remarkable how many keep a more or less complete record of their observations. It is, however, much to be regretted that the class of observations referred to are seldom of any service beyond affording some amusement to the observers themselves, although much time and trouble are often expended upon them. Now, in the course of this short paper, I wish to show how easily such observers might render their records of considerable value, not only to themselves, but also to all interested in similar investigations throughout the country.

The object these amateur observers principally have in view appears to be to endeavour to trace the relative earliness or lateness of the seasons in the locality in which they reside; in other words, the influence of the weather upon the natural objects which surround them. With this laudable object I, as a meteorologist and horticulturist, have the warmest sympathy. In order to obtain similar results from meteorological data, we have to take a more or less circuitous route, and then when all is done there is a sadly theoretical and unconvincing look about the conclusions we arrive at. Whereas, introduce only a few accurately-made phenological observations, and the dry bones of these statistics become at once clothed with life and meaning. Their records may not be nearly as precise as those derived from thermometers, sunshine-recorders, and rain-gauges; but on the other hand they have a happy knack of summing up a large mass of instrumental evidence, and presenting the issue in a clear and intelligible light.

In the present paper I propose to treat this subject from a meteorological point of view, and at the same time to confine my remarks entirely to plants as being the most dependable for this purpose.

The Selection of Species.—In making this selection we must above all things consider the observers, and not require of them more than is absolutely necessary to attain the object we have in view. For instance, it has been found by experience that those who have the requisite leisure, knowledge, and enthusiasm to make a large

number of observations correctly year after year are few and far between. Consequently the choice rests between a large number of plants with a very limited number of observers, and a small selection of plants with a large staff of observers. In my opinion, at all events for meteorological purposes, the number of plants cannot well be too small, nor can the observers be too numerous, provided they be trustworthy, and the observing stations equally distributed.

To select quite a small number of plants is, however, no easy matter, when there are so many to choose from, and so many considerations to be borne in mind. In the first place their average dates of blossoming should occur at regular intervals throughout the flowering season. In the second, they should be familiar wild flowers and common throughout the British Isles. Thirdly, they should be species not likely to be mistaken for others by any ordinary observer. And lastly, trees and shrubs, where practicable, should have the preference over low-growing plants. With so many requirements to satisfy, it is not to be expected that any short selection, however carefully made, will meet with the approval of every one. If, however, it complies fairly well with the considerations I have stated, I do not very well see how the results can fail to be satisfactory.

Uniformity of Observation.—We may have the most perfect selection of plants possible; we may also have a splendid staff of accurate observers; but unless the observations are made by all in precisely the same way, they will be scarcely worth the paper they are written upon, and it would be useless attempting to derive any satisfactory conclusions from them.

The most important points on which uniformity should be insisted upon are the following:—

The same individual trees and shrubs must be observed every year, and in the case of herbaceous plants those growing in the same spots. This is by no means a new rule, and yet it is one which has been perhaps overlooked more than any other, although the most important of them all. Many observers appear to think they have done all that is required of them if they enter on the recording sheet the date of the first flower of any plant on the list which they happen to come across during their rambles. Should this happen to be the first blossom of the kind in the whole district, they seem to consider that they have secured a great prize, and that their zeal is worthy of the highest commendation. Whereas were they to confine their attention to the one particular tree or group of plants they have decided to observe, their observation, instead of being altogether worthless, would supply the recorder with what he really wants. For it should never be forgotten that it is comparable observations, and those only, which are of any service to him. For the same reason the trees and other plants to be observed should be chosen with much care. For example, they should not be growing in very sheltered, or, on the other hand, in very exposed positions, for the entries made from them will not

then fairly represent the district in which they are situated, but one either warmer or colder than that district. Again, there will be found in almost every locality certain trees and other plants which, although not particularly exposed or sheltered, nevertheless, owing to some peculiarity of the soil in which they grow, invariably come into blossom either earlier or later than those around them. These also should be avoided. All trees and shrubs selected for observation should be of mature growth.

Supposing the foregoing important conditions to have been faithfully complied with, the next point is for the observer to note the opening of the first flowers on the selected plants. This is not so troublesome as may at first sight appear, for a little experience will soon show him how frequently each of the plants on the list should be visited. Of course this will depend on the character of the plant and also on the nature of the season, for some kinds of bud open much more quickly than others. Then, again, warm weather, particularly if it sets in suddenly after a cold spell, causes plants to rush into flower very quickly, whereas during continued cold they will often remain for a long time in the bud stage before developing a flower.

Concluding Remarks.—"And you call this a simple method of taking phenological observations?" it may naturally be asked. And so in practice I repeat it will be found to be. On this point I can speak from experience, having long since given up the numerous-plant system as incompatible with my many other occupations, in favour of the one I am now advocating, and which I find no difficulty at all in carrying out. Of course nothing can be done well without a certain amount of care and trouble; but allowing this, the duties of an observer, as I have defined them, may be summed up as follows. Having during the first year, and then once for all, selected about a dozen different plants for the purposes of observation, all he has to do afterwards is to watch diligently for the first flower to open on each of these twelve plants. And as they cover the entire flowering season, it is seldom that more than one tree, shrub, or group of plants need be under observation at a time.

The observer himself must necessarily be held responsible for the accuracy of the entries. Nevertheless it will readily be understood how his friends and the members of his family, by acting under his direction, can assist in making his observations even still easier than they really are, and at the same time more complete. During the absence of the observer such trained assistants are altogether indispensable.

The plants recommended for observation by the Royal Meteorological Society are as follows: Hazel, Coltsfoot, Wood Anemone, Blackthorn, Garlic Hedge Mustard, Horse Chestnut, Hawthorn, White Ox-eye, Dog Rose, Black Knapweed, Harebell, Greater Bindweed, Ivy—or thirteen plants in all.

One word in conclusion to intending observers. There is something peculiarly fascinating about keeping a phenological record, and the longer it is kept up, the more interesting and valuable does

it become. Moreover, it is singularly instructive. The very fact of making a few simple observations like those I have mentioned will be found to open the observer's eyes in a truly wonderful manner to the beauties and wonders of Nature around him. Then, again, it will greatly sharpen his powers of observation. Plants, birds, and insects of all kinds, hitherto unnoticed, at once become objects of more or less interest to him. Nevertheless, unpretentious as these observations may appear, they should not be undertaken in any light or trifling spirit, but with a settled determination to make them as trustworthy and complete as possible. In all scientific investigations of this character, reliability is of far more importance than completeness. It is therefore much better to leave out an observation here and there, than to enter one about the accuracy of which the observer has any doubt whatever.

If only for the reasons I have just given, this simple Science of Phenology will be seen to be one worthy of every encouragement from our Natural History Societies and Field Clubs throughout the country; for I venture to maintain that in no other way can an interest in most branches of Natural History be so easily developed and maintained.

I append the schedule of the Royal Meteorological Society, copies of which I shall be pleased to forward to any intending observer.

ROYAL METEOROLOGICAL SOCIETY.

Phenological Observations.

PLANTS.

(Date of Flowering.)

1. Hazel (*Corylus Avellana*).
2. Coltsfoot (*Tussilago Farfara*).
3. Wood Anemone (*Anemone nemorosa*).
4. Blackthorn (*Prunus spinosa*).
5. Garlic Hedge Mustard (*Sisymbrium Alliaria*).
6. Horse Chestnut (*Æsculus Hippocastanum*).
7. Hawthorn (*Cratægus Oxyacantha*).
8. White Ox-Eye (*Chrysanthemum Leucanthemum*).
9. Dog Rose (*Rosa canina*).
10. Black Knapweed (*Centaurea nigra*).
11. Harebell (*Campanula rotundifolia*).
12. Greater Bindweed (*Convolvulus Sepium*).
13. Ivy (*Hedera Helix*).

Instructions to Observers.

1. *Observe the same individual trees and shrubs each year, and as regards herbaceous plants, those growing in precisely the same spots.*—This is of the greatest importance. In the case of trees and shrubs they must be of mature growth. The particular plants

etc., selected for observation should be situated neither in very sheltered, nor, on the other hand, in very exposed positions, and should neither be abnormally early nor late in their flowering for the district. When from any cause any of the selected plants, trees, or shrubs cease to be available, other specimens of the same species similarly situated should be observed instead of them.

2. *Watch carefully for the appearance of the first flowers.*—A plant, etc., is to be considered "in flower" when the stamens of the first blossom on it *first* become visible. As soon as the date of one plant has been secured, watch for the appearance of the next on the list. If, unfortunately, the first flowering be missed by a day or two, the observer is requested to give the estimated date of first flowering, and to place an asterisk against the entry. Should the plant be estimated to have been in flower more than four days, no entry at all should be made, as the observation would be of no value whatever for the purpose of this investigation.

3. In the case of the hazel the *fertile* flowers are to be observed. They are little bright-red flowers which, as a rule, open directly after the barren flowers or catkins.

BIRDS.

1. Song Thrush (*Turdus musicus*), first heard.
2. Swallow (*Hirundo rustica*), first seen.
3. Cuckoo (*Cuculus canorus*), first heard.
4. Nightingale (*Daulius luscinia*), first heard.
5. Flycatcher (*Musicapa grisola*), first seen.
6. Swallow (*Hirundo rustica*), last seen.

Instructions to Observers.

1. The note of the song thrush must not be mistaken for that of the missel thrush, which is generally heard earlier. The notes of the missel thrush are less musical and connected. Its strain is altogether much shorter, and, being repeated many times in succession, it wants the variety of that of the song thrush.

2. The swallow may be distinguished from the house martin and sand martin by its back being of an uniform glossy steel-blue, almost black, by its long forked tail, and by the dingy white colour of its lower parts. The house martin has the rump and lower parts pure white, while the sand martin is of a mouse-colour above. The swift differs from the swallow in its more rapid flight, the peculiar narrowness of its outspread wings, and its general sooty colour.

3. Observers should be on their guard against imitations of the well-known note of the cuckoo.

4. The observer should be certain that it is the nightingale that is heard, as the song thrush also often sings late in the evening.

5. The flycatcher is a little greyish-brown bird fond of sitting on a post, rail, or perch, whence it can readily dart off and seize a fly, usually returning to its former station.

INSECTS.

1. Honey Bee (*Apis mellifica*), first seen.
2. Wasp (*Vespa vulgaris*), first seen.
3. Small White Butterfly (*Pieris rapæ*), first seen.
4. Orange-tip Butterfly (*Anthocharis cardamines*), first seen.
5. Meadow-brown Butterfly (*Epinephile Janira*), first seen.

Instructions to Observers.

1. The date when the hive-bee first visits flowers.

3. This must not be mistaken for the large white butterfly, which generally makes its appearance a little later than the small white one.

General Instructions.

1. Place the dates against the names of the plants, birds, and insects in the lists, and send the forms to Mr. E. Mawley, Berkhamsted, Herts, quarterly, viz. on March 1st, June 1st, September 1st, and December 1st.

2. Notes *made at the time* on any exceptional weather, and its influence on farm and garden crops, trees, birds, insects, etc., will add greatly to the value of the returns. For example, the effect on vegetation of a severe frost, of heavy rain, snow, or hail, of a prolonged drought, etc.

3. Some one should be instructed to make the observations during the absence of the observer.

XVII.

NOTES ON BIRDS OBSERVED IN HERTFORDSHIRE DURING THE YEAR 1890 AND THE EARLY PART OF 1891.

By George Rooper, F.Z.S.

Read at Watford, 16th March, 1891.

There are few subjects connected with the study of natural history more interesting or more incapable of explanation than the migration of birds. The moving cause is obvious enough—the failure of food or the inclemency of the weather in the locations from which they flee. But what the guiding-power is which carries even short-winged birds across not only vast tracts of land, but considerable arms of the sea, to their destined abode, is a mystery. All we know is that year by year, at the same appointed times, the same birds seek their appointed places. We can only attribute it to the marvellous workings of what we call "instinct," implanted in their nature. Such birds are usually classed as "migrants." But I think that this term is used in too limited a sense, when applied, as it is exclusively, to foreign visitors or to birds which being bred here seek foreign lands when winter approaches.

All birds are more or less migrants. Even the ubiquitous sparrows forsake the rickyards and the dwellings of men in the autumn, and seek in great flocks the fields of ripened corn. The thrushes which swarm on my yew-trees when the berries are ripe were not bred in the garden, nor when the crop is devoured will they there remain. A few pairs of wood-pigeons pay me an annual visit in March, and leave me in October or November. The thrushes, I think, travel northward, in company with their congeners, the redwings, to feast on the abundant berries of the rowan, the thorn, and the bramble. The comparative failure of wild fruits, owing to the lengthened frost this year, drove the poor hungry birds back again, southward, the mistaken result of blindly following their instincts. The weather in the north this winter was many degrees warmer than in the south, and the thrushes which reached our southern coast perished in vast numbers; more than 300, I am assured, were picked up dead in one garden at Bournemouth. Rooks, as we all know, leave their nesting-trees when the season is ended, and seek "fresh fields and pastures new." Plovers, starlings, and many other birds abandon their breeding-stations when the young can fly and shift for themselves, and collect in distant quarters in vast flocks. These, and indeed all birds, as I have said, are migrants, properly so called; that is, they change their place of residence as circumstances seem to require.

Birds which spend only a portion of the year with us, and seek foreign climes for the remainder, may, I think, be called emigrants or immigrants. In the first category I would place our summer birds, the swallow, the nightingale, the cuckoo, and others, which, seeking our shores in the spring, acquire what I may call a settlement, having a domicile in the shape of a nest, and bringing up a

family. They leave us in the autumn, when the supply of food fails. On the other hand, the birds which breed in foreign climes —the woodcock, the fieldfare, the shrike, and others which seek our shores as winter approaches—are more properly immigrants.

This disquisition, however, although congenial to our subject, is hardly within the province of my report, which is to record the appearance of such rare birds, or rather rare visitors, as during the past year have either come under my own observation, or whose appearance has been kindly communicated to me by members of the Society. To this record I have ventured to add, as I did last year, some notes on the personal history and peculiarities of each bird. The bitter winter we have lately experienced has made the list an exceptionally long one.

The first bird on my list is the Smew (*Mergus albellus*).—Mr. G. J. Buller, of Welwyn, kindly informed me that a female smew was killed in that neighbourhood on the 10th of January.* Its appearance in Hertfordshire is a most rare occurrence. I doubt if it has ever been recorded before. The smew is a handsome black and white sea-bird, about two-thirds the size of a goose, and nearly related to the goosanders and mergansers. Its diet is entirely of fish, to enable it to catch which it is furnished with a long hooked bill with a formidable array of sharp teeth, directed backwards, so as to more securely hold its slippery prey. Like all fish-eaters, the bird is an accomplished diver. It is a winter visitant, and frequents the northern lakes. I have never seen this bird alive, but its cousin, the merganser (*Mergus serrator*), was sent to me by the late Mr. Day some years since. I can hardly, however, be said to have seen it, for my cook, who was not an ornithologist, received it in my absence, and promptly dressed it for dinner. I only identified the bird after rescuing its head from the dust-heap. Both birds are coarse, strong, and unfit for food.

The Goosander (*Mergus merganser*), which, however, I only recognised by the description, is said to have been shot near St. Albans, but the description Mr. Lewis favoured me with at second hand leaves some doubt on the subject. The goosander is also a fish-eater, and furnished with the same long bill and sharp teeth as his congeners, the merganser and the smew. It is a beautiful bird, conspicuous by its red bill, and the blending of many colours in the plumage. Its length is about two feet.

The Puffin (*Alca arctica*).—I observed in the 'Times' that a bird of this species was picked up by Mr. Bolton, of Copped Hall, near Totteridge, during the frost. It was described as "in a very exhausted condition." No wonder, for it is a short-winged, bad-flying bird, and could not have tasted a morsel of food from the time it left the coast. Mr. Bolton seems to have done his best, as a charitable man would, to feed and revive the poor wanderer, but it absolutely refused the dead fish which he offered it, probably because it was dead, and at the expiration of three or four days it died. As I said, the puffin is a bad flyer, and a stay-at-home bird,

* The winter records are all for the winter of 1890–91.—Ed.

never, in fact, leaving the coast, and very rarely the sea. How he got to Hertfordshire, unless he came by train, I cannot guess. He is, in fact, a purely sea-bird, seldom coming to the land, except to breed. The nest is always in a hole, some three feet or more deep, excavated by the bird itself, unless a rabbit-burrow is handy, in which case, as the sparrow treats the swallow, and the fox the badger, "Brer Rabbit" is unscrupulously ejected. "Might is right," and poor bunny has no chance against the powerful bill and sharp claws of the puffin. The bird lays one egg only, and it is as well, if you wish to take it, to dig it out, as the mother bites viciously with her powerful bill, and makes no scruple of attacking the intrusive hand.

There is no more attractive place of rest for the wandering bird than the beautiful domain of Munden, and any one likely to take up its *permanent* quarters there would, I know, be carefully protected by its owner, the Hon. Arthur Holland-Hibbert. No less than four rare visitants were observed by him during the frost, whose appearance he was kind enough to communicate to me.

The Tufted Duck (*Anas fuligula*).—This rare bird, rare, at least, in these latitudes, was shot by Mr. Hibbert, or by one of his keepers, during the frost. The bird, like the rest of the species of its genus, is an inhabitant of northern regions, making this its winter residence only. It wears a tuft on its head; hence the name. Its size is about two-thirds that of a wild duck.

The Pochard (*Anas ferina*).—Mr. Hibbert's keeper shot a pochard about the same time. This bird is also known as the dun-bird or red-headed pochard, from the prevailing colour of its head, a deep, uniform rufous. It is a winter visitant to these isles, and, though rarely seen so far inland as Hertfordshire, is found in great flocks in the localities it affects. The pochard is a true duck, and excellent eating; in fact it is closely allied to the far-famed canvas-backed duck of America. There it obtains an additional flavour from feeding on the wild rice and a species of grass-wrack or sea-grass which abounds in the neighbourhood it frequents. Like most of the duck tribe the pochards are night-feeding birds, and their shrill whistle may be heard at all times during the night as they seek their feeding-ground. In my young days they were common enough on or about the great lake known as Whittlesea Mere, over which I have often slowly punted, and which I now pass over when I travel northward by the Great Northern Railway. Wild fowl were cheap in those days. Ducks, which were designated as "whole birds," were sold at 1*s.* each, and other wild fowl, including dun-birds, widgeon, teal, etc., as "half-birds," at 6*d.* each.

The Bean Goose (*Anser segetum*).—Another rare bird, the bean goose, is recorded by Mr. Hibbert as having visited the water in his park. We have five or six species of wild geese which visit our climes in the winter. The particular bird here recorded is not what is considered to be the type or origin of our tame geese. That honour is conferred on the wild goose proper (*Anser ferus*), from which the bean-goose differs but slightly. Its main peculiarity is

the existence of a dark mark on the upper mandible, the shape and colour of a bean, from which it takes its name, and not, as stated in many books on natural history, from its especial affection for beans, which affection it shares in common with its congeners. As to either bird being the progenitor of our heavy, waddling, barnyard goose, I do not believe it. There are many essential differences, which in my opinion never could have arisen from domestication. Several flocks of wild geese were seen to pass over during the frost; one flock in particular flew over our heads as we were hunting in the neighbourhood of Leavesden.

The Bittern (*Botaurus stellaris*).—The bittern, though now so rare, was in my young days comparatively common in the fens of Huntingdonshire and Cambridgeshire. I have heard my father say that he has shot as many as six or eight in a season. The bittern is a handsome bird, 24 inches in height; where not extirpated it is resident with us throughout the year. Although seldom met with in the flesh, a stuffed specimen may be seen in the window of every taxidermist, and in a glass case in every collection. Its food consists of frogs, mice, fish, and occasionally, I think, snakes. Its chief peculiarity is its note—a harsh, booming noise, produced, the fen-men say, by the bird thrusting its bill into the bog when he makes it. This, of course, is not the case; but its note, like that of the corncrake, being emitted very close to the ground, it is difficult to fix the exact spot from whence it proceeds, and its wonderful power of creeping rapidly through the sedge and grass makes it a hard matter to localise. In shooting it is a very difficult bird to put up. It was formerly esteemed a delicacy for the table. In Huntingdonshire, from its note, it was called the "buttledebump." One was observed during the frost by Mr. Robert Barclay, of High Leigh, Hoddesdon, who was kind enough to communicate the fact to me.

The voices of birds seem to me to be always in unison with the character of their places of resort. The sweet song of the blackbird is in unison with its sylvan haunts; the wild cry of the gull blends harmoniously with the hoarse murmur of the waves; the scream of the eagle harmonises well with the savage scenery around which it is heard; and the booming of the bittern is in unison with the dreary, flag-covered swamp wherein it delights to dwell.

Many instances of albino birds have been mentioned to me. Though curious as individuals, they cannot be classed with the rare birds which I have had the honour and pleasure of introducing to you. Most albinos, I may say, are young birds. Mrs. Panton sent me an account of a white sparrow which she observed in her garden, and which was as confiding—I may say as impudent—as sparrows generally are. I saw a piebald blackbird in my garden, and hastily put him down as that very rare bird, the ring-ouzel (*Turdus torquatus*); but it was in the winter, and as ring-ouzels are only summer visitants, I conclude that it was a pied blackbird. It is fifty years since I saw a small flock of ring-ouzels in an orchard in Huntingdonshire.

Dr. Brett tells me that the siskin or aberdevine (*Carduelis spinus*) was very abundant in the autumn. It is principally a winter visitant, but not infrequently breeds in the north.

The Green Woodpecker (*Picus viridis*). — That indefatigable observer, Mr. Lewis, tells me that the green woodpecker has greatly increased in numbers. I observed one the other day in my own garden. One that he saw at Knebworth was of course shot by that enemy of all except game-birds, the gamekeeper. Mr. Solly also expresses an opinion that this bird is greatly on the increase. I hope so. It is not only beautiful and harmless, but really useful in destroying the insects which produce rot in trees. As I dilated on the general habits of this beautiful bird in my last year's report, I will not further comment on him, but I may tell you the story of its near relation, the great black woodpecker, which in Norway is called "Gertrude's bird." This is the legend on which the name is founded:—Gertrude was a baker, and she wore a red mutch on her head. A holy man begged the gift of one of the cakes she was baking, which she churlishly refused; the holy man, who was possessed of miraculous powers, and not proof against the pleasure of revenge, pronounced her doom—that she should be "transformed into a bird, bound to find its food betwixt bark and bole for ever, and never drink but from the raindrops." So the old lady was changed into a bird forthwith, and flew away up the chimney. She is now seen with her red mutch on her head, and her body all black with the soot, seeking her food under the bark of the trees, and is never seen to drink from lake or river.

The Sea-Eagle (*Haliaëtus albicilla*).—An immature specimen of this bird, which figures in the papers as a "splendid specimen of the golden eagle" (*Aquila chrysaëtus*), was cruelly done to death by a gamekeeper near Hitchin, who seems to have fired four or five shots into the body of the poor famished bird. I have not seen it, but, from the description, I have no hesitation in assuming it to have been a young white-headed eagle. Until the second year it is difficult to distinguish the one from the other, and whilst the white-headed eagle is comparatively common, the golden eagle is, unhappily, almost extinct. However, if any one here can get a sight of the bird, which has no doubt been stuffed, there can be no mistake in the matter. Besides minor differences, which I need not detail, the golden-eagle's legs are feathered down to the claws; while those of the sea-eagle are bare. The eagle owes much to his noble appearance, and is credited with corresponding mental attributes, to which he is by no means entitled. I look upon the bird as a rank impostor; sluggish, cowardly, and gluttonous. He will, like the vultures, feed on any dead carcase he may find, and his proudest boast is to murder an unprotected or sickly lamb, or to strangle a timid hare. The long-winged falcons are the really noble birds, striking at quarries capable of resistance, such as herons and rooks, and disdaining to eat of any bird or beast which they have not themselves killed. The eagle is called "the king of the birds," but its claim to the dignity is disputed by the wren.

Do you know how the wren became the king of the birds? On a certain time the birds assembled to choose a king, and they resolved that the bird which flew the highest should receive the honour. The eagle at once soared upwards till he was lost to sight in the clouds, but when he could fly no higher, the little wren, which had nestled in his feathers, sprung out, and after flying a few feet above him, descended, and claimed the regal dignity. There is a legend about the wren, too, common in the Isle of Man. It is said that an evil spirit in the shape of a beautiful woman would tempt men to the top of a cliff down which she disappeared, and when her follower peeped over to see what had become of her she came behind and pushed him down the precipice. Whether a stronger witch, or a knight-errant, overcame her, I know not, but she was overcome, and changed into a wren. This was on St. Martin's Day, and it is the custom, both in that island and Ireland, to hunt and destroy the little bird on that day. An Irish song which refers both to its royalty and death begins thus—

> The wren, the wren, the king of all birds;
> On St. Martin's Day it was caught in the furze.

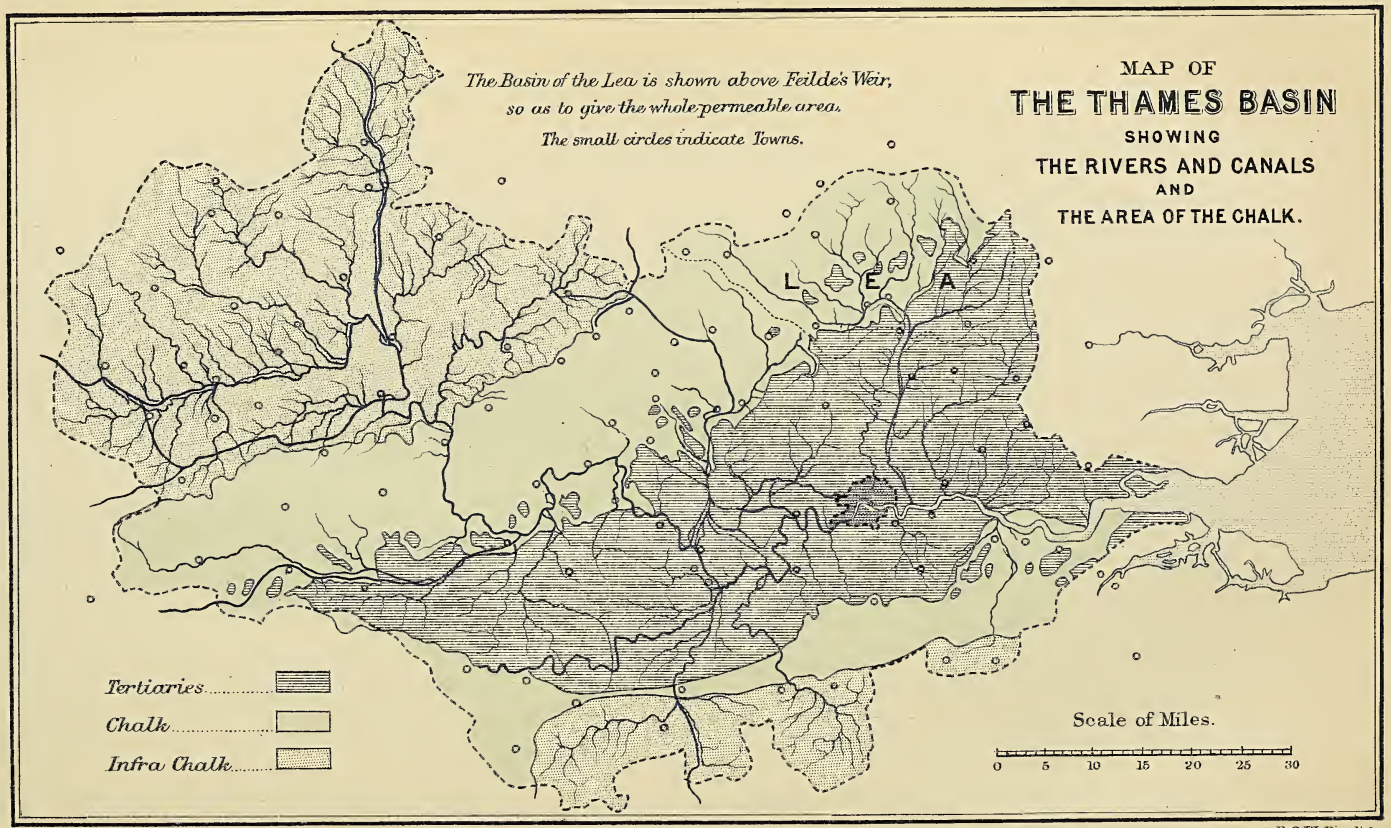
The Dunlin (*Tringa alpina*).—Mr. Lewis tells me that a dunlin was killed at Redbourn in December last. He also mentions a curious skylark, almost black, which, however, I cannot identify.

The Black-backed Gull (*Larus marinus*).—On the 30th August Mr. Hopkinson reported that a flight of black-backed gulls had been seen passing over Balls Park, Hertford. One, probably of the same flock, was shot by Mr. Majendie near Bayford Hall Farm, Hertford.

The Curlew (*Numenius arquata*).—Mr. William Bonner Hopkins, of Fair Hill, Berkhamsted, records a pair of these birds, which he observed flying over his garden in September. The same gentleman saw also a flock of wild geese which were flying very low.

Some records of the arrival of various summer visitants have been furnished to me, but, as they differ very little, I only append that of Mr. J. J. Willis, of Harpenden. Summer birds, in fact, are wonderfully regular in their movements. The song thrush (probably the missel) was heard on January 16th; the skylark, January 12th; the nightingale arrived on April 28th; the cuckoo, April 12th; the swallow, April 14th; the house-martin, May 11th; and rooks built on March 4th.

I feel that I ought to apologise for the length to which my record has run, but, owing to the unprecedented weather we have experienced during December and January, an unusual number of rare visitants claimed a notice at my hands.



J. Hopkinson, del.

F. S. Weller, lith.

XVIII.

WATER AND WATER-SUPPLY, WITH SPECIAL REFERENCE TO THE SUPPLY OF LONDON FROM THE CHALK OF HERTFORDSHIRE.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc., President.

Read at Hitchin, 13th March, 1891.*

PLATE IV.

Water being the chief necessary of life, its presence on the surface of the earth, or within easy access underground, has been the most potent factor in determining the position of sites for human habitation in all parts of the world. Most of our chief towns, and all our older cities, towns, and villages, are situated on the banks of rivers, the water in which, so long as it was uncontaminated, would form the only source of supply for drinking and other purposes. As the population increased and the towns extended, first along the river-banks and then at a distance from them, other sources of supply would be sought; and for ages the presence of a superficial stratum of sand or gravel over a bed of clay must have determined the direction of growth, for in such strata water would easily be obtained by sinking shallow wells.

Water is present almost everywhere, and often in a far larger proportion than might be supposed. It forms more than 70 per cent. of our own bodies, even our bones and muscles being largely composed of it, and the proportion in the vegetables we eat is from 75 to 95 per cent., while some fruits contain a still larger proportion. It is universally present in the atmosphere in very varying proportions, but averaging about $1\frac{1}{2}$ per cent. when quite invisible. Without it everything on the earth would be scorched, while the direct rays of the sun, however intense, would scarcely warm the air in the slightest degree. But for the moisture ever present we could not bear the sun's heat-rays, while the air, in the shade, were it not for radiation of heat from the earth, would be more intensely cold than we can possibly imagine, or than we could possibly bear. It is universally present in the earth as far down as we have been enabled to penetrate, entering into the composition of all kinds of rocks, even such as are as compact in structure as glass. It is not every rock, however, from which we can procure water. We could not possibly get a supply from our Hertfordshire Conglomerate, but we could drive off a considerable quantity of water of consolidation by calcining it. On the other hand, soft chalk, which, Prof. Ansted says, "will take up half its own bulk of water and yet hardly appear wet,"† will part with it freely. Chalk, therefore, like sandstone, is a valuable water-bearing rock, and although water percolates more rapidly through sandstone than it does through chalk, this is

* Including portions of papers read at St. Albans, 18th Dec. 1890, and at Hertford, 27th Jan. 1891.

† 'Applications of Geology to the Arts and Manufactures,' p. 56.

fully compensated for by chalk being more cracked and fissured than is sandstone. It is also easily acted on by water, mechanically by attrition, and chemically, with the aid of carbonic acid gas, by dissolution.

Absolutely pure water consists of two gases, oxygen and hydrogen, chemically combined, a fact first experimentally proved by Cavendish in 1782. Exactly one volume of oxygen combines with exactly two volumes of hydrogen to form water; but the water thus produced equals in volume only about the 2000th part of the gases producing it, or, more exactly, one volume of water is the product of 655 volumes of oxygen and 1310 volumes of hydrogen. As oxygen is sixteen times, or, again to be precise, 15·96 times heavier than hydrogen (the lightest element known), it follows that nine parts by weight of water are composed of about eight parts of oxygen and one part of hydrogen. Air, on the other hand, is only a mechanical mixture of oxygen and nitrogen, in the proportion of one volume of oxygen to nearly four of nitrogen, with a small portion of carbonic acid gas. These gases, not being in chemical combination, vary in their proportions, and the oxygen of the air being more soluble in water than the nitrogen, rain in falling carries with it the greater amount of oxygen, so that the air always contained in rain-water has little more than two volumes of nitrogen to one of oxygen. Carbonic acid gas is more soluble in water than is either oxygen or nitrogen; but it exists in such a small proportion in the air,—about 0·04 per cent.,—that there can be but very little in fresh rain-water. In falling on the surface of the ground, however, the rain removes and carries with it much decaying animal and vegetable matter, which is rich in carbon, in fact consists almost entirely of organic carbon and water. The free oxygen in the water, that is, the surplus oxygen dissolved from the air, combines with this carbonaceous matter, forming carbon dioxide (carbonic acid gas), which is a chemical compound of carbon and oxygen in the proportion of one equivalent of carbon to two equivalents of oxygen, as its name implies. This oxidation or slow burning of animal and vegetable matter is a chemical process which purifies the water by depriving it of organic carbon, and, as a flowing river, especially where it is rapid, is constantly dissolving out of the air a greater proportionate amount of oxygen than of nitrogen, the longer the run of the river, the less organic carbon and the more carbon dioxide will its water contain, provided that there be no further access of decaying animal or vegetable matter. While, however, dead organic matter is thus rendered innocuous, this cannot be said of living matter, for we have no more reason to think that any length of run in a river will destroy the living germs of disease than that it will destroy aquatic plants or fish.

It is due to the presence of carbon dioxide, thus produced from the union of the oxygen of the air and the carbon of organic matter, that water percolating either directly into the chalk, or first through a porous bed of either gravel or sand, has the power of dissolving the chalk through which it passes. Chalk is a carbonate

of lime or calcium carbonate, a chemical combination of carbon dioxide and calcium oxide or lime in the proportion of one equivalent of each, and is insoluble in water; but the addition of a second equivalent of carbon dioxide converts it into bicarbonate of lime, which is soluble in water. Water which has percolated through chalk, and thus holds bicarbonate of lime in solution, is termed hard. By adding to such hard water a certain amount of lime-water, prepared by driving off by heat the carbon dioxide in chalk, to convert the chalk into calcium oxide or quick-lime, and then slaking this by adding water, the bicarbonate of lime is again converted into a carbonate, the previously added equivalent of carbon dioxide forsaking the bicarbonate, which it leaves as a carbonate (chalk), for the lime in the lime-water, which it converts back again into the carbonate (chalk) from which it was made. This is the reaction upon which is founded Clark's process of softening hard water, the chalk thus re-formed sinking by gravitation, and leaving in the water only a very small quantity of bicarbonate of lime.

Pure water is perfectly colourless; every ray of light falling upon it is either reflected from its surface or absorbed, so that if we could look upon an infinite depth of water absolutely free from matter in suspension, it would appear as black as ink. A very slight admixture of solid matter in fine suspended particles gives it a deep indigo-blue colour; a little more, an ultramarine; while, as the quantity increases, the colour changes to a bluish and then to a yellowish green. This is caused by the gradual absorption of heat by the water. The invisible thermal rays are first absorbed, then at greater and greater depths the rays which are both thermal and visual,—red, orange, yellow, green, and blue in succession,—the light we see being that reflected from matter in suspension, from deeper and deeper water as such matter is less and less in quantity. Professor Tyndall has shown* that this is the cause of the varying colour of the sea, and it also accounts for the beautiful blue and bluish-green colour of the water in the subsidence tanks used in Clark's softening process.

Water passes from the fluid to the solid or the gaseous state with comparatively moderate changes of temperature and pressure. It is at its greatest density at 39°·34 Fahr. It dilates uniformly from this point with increase and decrease of temperature, so that at 46°·68 it has the same volume as at 32°. At this latter point a slight movement will cause it to freeze, when it suddenly expands with an enormous force, but if kept perfectly still it may be cooled down to from 10° to 20° without congelation. Under a barometric pressure of 30 inches it usually boils at 212° Fahr. (=100° Centigrade), but here again perfect stillness will retard the ebullition. If the pressure of the air were doubled, it would not boil until its temperature rose to 240°; if the pressure were altogether removed, it would boil at 67°. The reduction in pressure on very high mountains makes cooking by boiling almost impossible, the water flying off as steam at too low a temperature.

* 'Fragments of Science,' vol. i, pp. 218–226 (6th Ed. 1879).

Water evaporates at all temperatures; even the coldest ice gives off some vapour; but it is only when the water is boiling that the vapour is formed below the surface. Transparent aqueous vapour is 37½ per cent. lighter than atmospheric air, each particle of water, on conversion into vapour, absorbing heat enough to raise the temperature of 960 such particles one degree. The amount of evaporation increases as the temperature rises, as the air is drier, and as the surface exposed to the air becomes greater. From still water there is, therefore, the least amount of evaporation; when the water is agitated, the evaporation increases; from rough moist ground it is greater than from water; and from ground covered with vegetation it is at least doubled. Wind, also, increases the amount of evaporation by passing dry or comparatively dry air rapidly over the moist surface, which thus more freely parts with its moisture than it would do if that moisture remained longer in contact with it.

The circulation of water in the atmosphere, brought about by the vapour falling as rain (or snow), and thus allowing the sun to draw up more vapour to take the place of that which is abstracted, is only in part due to the fact that warm air can retain more moisture than cold air, so that a cold current meeting and mixing with a warm moist current supersaturates the air, causing some of the moisture it contains to fall as rain. If the temperature and humidity varied in the same proportion, all mixtures of currents of different temperature would have the mean degree of humidity of the two currents; but the amount of vapour air can contain not only increases with the temperature, but it increases in a greater ratio than does the temperature. It follows from this that the air formed by the mixture of any two saturated currents of air of different temperature will always be supersaturated.

The amount of evaporation forms a measure of the heating power of the sun, and as that is greatest in the tropics and decreases towards the poles, the evaporation must vary correspondingly. But the rainfall also is greatest in the tropics, and it is doubtful how much of the heat drawn up with vapour from tropical seas is conveyed to higher latitudes and there liberated when rain falls. Still there is a constant circulation going on in the atmosphere as there is in the ocean, by which warmth is conveyed from the hotter to the colder parts of the earth, thus ameliorating the climate, cold currents flowing in the reverse direction. Into the details of this atmospheric and oceanic circulation it is unnecessary to enter here; but it may be of interest to give one instance of the heat due to rainfall. On the west coast of Ireland the mean rainfall is about 45 inches, and the heat given out by this amount of rain is nearly half that due to the direct rays of the sun. It has been calculated by Professor Haughton* that while the direct heat of the sun received there in one year would melt a layer of ice 61·4 feet thick, the indirect heat of the sun due to rainfall would in the same time melt 30 feet of ice.

* 'Lectures on Physical Geography,' p. 128.

Even snow protects the ground from frost, being, owing to the air confined within its interstices, a bad conductor of heat; and without the heat of the sun, the vapour required for the formation of snow could not rise. It has, nevertheless, been assumed that the Glacial period must have been one of general cold, and might therefore be due, in part at least, to the earth receiving from the sun a less amount of heat than it now does. But the fact is that the contrary is more likely to have been the case, for the abundance of snow depends upon the humidity of the air, and therefore the immense amount of snow that must have fallen to form an ice-cap over the greater part of Northern Europe necessitates a great heating power of the sun to raise the amount of vapour required to form that snow.

The source of all water-supply is rain, and in this country the chief characteristic of rainfall is its great variability. This masks any secular variation there may be in our time, and baffles all attempts at prediction from one year to another, and almost from one day to the next. We have every reason to believe, however, that the rainfall on our globe is decreasing. We infer it from what we know must have been the early history of the earth, and we have both historical and geological evidence of it. The source of all rainfall is evaporation, which is dependent upon the heating power of the sun. But it is not to the secular cooling of the sun, of which we have no certain evidence, that I am alluding, but to that of the earth, of which we have precise data; and also to alterations in the configuration of the earth's surface.

Presuming that the total amount of water in the atmosphere, on the surface of the ground, as in rivers, lakes, and seas, and within its crust, is a constant quantity, when the earth was very highly heated the whole of it would be in the atmosphere; as the surface slowly cooled, the water which fell upon it would no longer be driven off as steam, but would accumulate in seas and run off the higher land as rivers into these seas, but none would yet be able to percolate into the rocks, owing to their still being in a heated condition. There would then be a more rapid circulation of water between the earth and its atmosphere than there is now; in other words there would be more evaporation and more rain. As the earth continued to cool, water would gradually percolate into its porous strata, but would be driven off whenever it reached the plane of temperature of its boiling-point, this plane getting gradually lower and lower, until now it is at a distance of about 10,000 feet from the surface, where the boiling-point of water will be considerably higher than 212°. Our constant quantity of water, all at one time in the atmosphere, thus first became divided between the atmosphere and the surface of the earth, and then between the atmosphere and the surface and interior of the earth, and with a gradually lessening quantity above the surface, there must be a gradually decreasing evaporation and rainfall.

This cause of a decreasing rainfall is cosmical, and it will, without a reasonable doubt, eventually reduce our earth to the same

state that the moon is now in; its surface and atmosphere will be entirely deprived of water, and eventually its atmosphere also will be dissipated.

The second cause is purely a geological one. The higher the land, the greater is the rainfall, and we know that denudation, where the counteracting effects of upheaval have been absent, must have greatly lessened the height of our hills and deepened our valleys. On the Chalk, as in Hertfordshire, although the wasting effects of sub-aerial denudation are imperceptible to us, there is no less surely a gradual lowering of the surface of the ground.

The third cause of decreasing rainfall, which has only been operating in comparatively recent times, is the disappearance of forests. There can be little doubt but that the greater part of Hertfordshire has within historic times been one vast forest. In the reign of Edward the Confessor the country between London and St. Albans, "as well as all parts of the Chiltern," is said to have been "covered with thick woods and groves."* Even since the county was first mapped by our Ordnance surveyors, the Hatfield Woodhall woods have been converted into arable land; and as trees anywhere in England now die, how seldom it is that others are planted in their place!

These causes of decreasing rainfall, all of which are in operation at the present time, are so slow in their action that their results are inappreciable to us; but that the rainfall has at one time been much greater than it is now, the existence all over the world of dry valleys and river-beds affords sure evidence. Dr. Livingstone was much impressed with the evidences of the desiccation of the southern portion of Central Africa. One large tract between the Orange River and Lake Ngami, he says, "has been called a desert simply because it contains no running water and very little water in wells. . . . It is remarkably flat, but intersected in various parts by the beds of ancient rivers." He traversed a high road "which lies generally in the bed of an ancient river or wady that must formerly have flowed north to south." And again he says of this desert: "The soil is sandy and there are here and there indications that at spots which now afford no water whatever, there were formerly wells and cattle stations."† A similar account has been given of Northern Africa. In north central Asia, the great desert of Gobi, a sand-waste from half to three-quarters of a million of miles in area, was not always the sterile, waterless, and treeless region it now is. It was formerly the seat of many large and flourishing cities, and must therefore have been fairly well watered; but the native Mongols cut down the trees, the rainfall decreased, and the sand advanced and buried the cities. The Dead Sea was at one time 150 miles in length, and its waters stood 1300 feet higher than they do now, this diminution in extent and depth being due to a decreasing rainfall; for there are waterless gorges over a thousand feet in depth leading into it, and down them powerful rivers must

* Newcome's 'History of the Abbey of St. Alban,' pp. 38, 39.

† 'Missionary Travels and Researches in South Africa,' pp. 47, 53, 54.

once have flowed, as is shown by the extent of denudation they have undergone. In North America the cañons of the Colorado region, and the numerous eroded valleys, now dry, or having but a small fraction of the water flowing in them that they must at one time have had, bear the same testimony to a greatly-decreased rainfall in the present day.* We need not, however, go beyond the limits of our own country, nor even of our own county, for evidence of this. The numerous dry valleys in the Chalk of Hertfordshire and elsewhere are silent witnesses of a former time when rivers flowed in them at a higher level than they would do now, for a vast amount of chalk has been removed by denudation and carried into the sea. The plane of saturation must then have been much higher than it is now, and the rainfall much greater. The natural inferences are that the rainfall is decreasing, and that the plane of saturation will from this in addition to other (cosmical) causes become lower. In our generation, however, the effect of the *artificial* lowering of this plane only need be feared, and that it is to be feared has been ascertained by investigations which have been made on the circulation of water in the Chalk and in other permeable rocks.

The systematic collection of information on the circulation of underground waters was commenced in this country in the year 1874, when, at the meeting of the British Association for the Advancement of Science held at Belfast, a Committee was appointed for the purpose of investigating the circulation of the underground waters in the New Red Sandstone and Permian formations of England, and the quantity and character of the water supplied to various towns and districts from those formations. In 1877 the enquiry was extended to embrace the Jurassic rocks, and in 1881 to the investigation of the circulation of water in the whole of the permeable formations of England. Thus it was not until the York meeting of the British Association, in 1881, at which the Committee presented its seventh annual report, that the Cretaceous rocks were included in the field of investigation, and therefore the underground water in the Chalk has received much less attention from the Committee than that in the Jurassic, New Red Sandstone, and Permian rocks; in fact, with the exception of one or two well-sections which extend into the Chalk, the only information on the circulation of water in this rock is contained in the last two reports (those presented in 1889 and 1890), and in each instance the information is derived from papers by Mr. H. George Fordham on the height of water in wells in the north of our county, which have appeared in our 'Transactions.'†

Many years before this Committee was appointed, however, the subject of underground water in the Chalk had received a considerable amount of attention. The late Rev. J. C. Clutterbuck was, I believe, the first who thoroughly investigated it. In 1840 he wrote a letter to Sir John Sebright, which was published in the

* For authorities see Prof. Hull's 'Text Book of Physiography,' pp. 176–180.

† 'Trans. Herts Nat. Hist. Soc.,' Vol. V, p. 20; Vol. VI, p. 31.

following year, "On the injurious consequences likely to accrue to a portion of the County of Hertford if the London and Westminster Water Company should carry into effect their project of supplying the Metropolis with Water from the Valley of the River Colne;" in 1842 he contributed a paper to the Institution of Civil Engineers on the water-level in the Chalk under London, continuing it in the following year; in 1850 he contributed another on the depression of the Chalk water-level under London; and in 1876 he read a paper before our Society on the "Geology and Water-supply of the Neighbourhood of Watford."*

Before Mr. Clutterbuck commenced to publish the results of his investigations, the late Mr. John Dickinson established a percolation-gauge at Nash Mills with the object of ascertaining the amount of water which percolates into the Chalk, so that he might predict the future flow of the River Gade, and so take no more orders for paper than he would be able to execute, the output from Messrs. Longman and Dickinson's mills then being limited to the water-power of the river; this was in the year 1835. Earlier still, in 1833, he set up a rain-gauge, evidently with the same object, but he doubtless soon became aware that the rainfall afforded no sure guide to the future height of the underground water, which height determines the amount of perennial flow of rivers deriving almost the whole of their supply from springs in the Chalk.

The investigations of the Underground Waters Committee of the British Association are confined to variations of water-level in wells, the quantity and quality of the water obtained from them, and the sections passed through in sinking wells and bore-holes; and the information furnished by the Committee in the annual Reports of the British Association is derived from replies received to the following queries,† and occasionally from published data. I omit the queries which do not affect our county.

1. Position of well or wells with which you are acquainted.

1a. Date at which the well was sunk. Has it been deepened since?

2. Approximate height of [the surface of the ground at] the same above the mean sea-level.

3. Depth from surface to bottom of shaft of well, with diameter. Depth from surface to bottom of bore-hole, with diameter.

3a. What is the extent and number of the horizontal drift-ways, if any?

4. Height at which water stands before and after pumping. Number of hours elapsing before ordinary level is restored after pumping.

5. Quantity capable of being pumped in gallons per day.

* 'Trans. Watford Nat. Hist. Soc.,' Vol. I, p. 125.

† The Secretary to the Committee, Mr. C. E. De Rance, 28, Jermyn Street, London, S.W., will forward, on application, copies of the schedule containing these queries. If, after insertion of information on any one or more of the points referred to, the schedule is sent to me, the information will be copied for publication by the Society, and the schedule will be forwarded to Mr. De Rance.

6. Does the water-level vary at different seasons of the year, and how? Has it diminished during the last ten years?

7. Is the ordinary water-level affected by local rains, and if so in how short a time? And how does it stand with regard to the water in the neighbouring streams?

8. Analysis of the water, if any. Does the water possess any marked peculiarity?

9. Nature of the rock passed through, including covering of drift, with thicknesses.

10. Does the cover of drift over the rock contain surface-springs?

11. If so, are they entirely kept out of the well?

12. Are there any large faults known to exist close to the well?

For the complete elucidation of the phenomena of underground water it is necessary to combine with the points investigated by the British Association Committee with regard to wells, results of observations of rainfall, evaporation, and percolation, for each of which a different kind of gauge is required.

The rain-gauge should preferably be five inches in diameter,* though gauges eight inches in diameter are frequently used. At Rothamsted Messrs. Lawes and Gilbert have circular gauges five and eight inches in diameter, and a rectangular gauge $7\frac{1}{4}$ feet by 6 feet, being $\frac{1}{100}$ of an acre in area. The top of the gauge should be one foot above the surface of the ground, and it is advisable to have a deep rim above the funnel in order to collect snow. The receiver should hold at least six inches of rain, but, for the collection of small quantities, there should be an inner collecting-can or bottle, which in very heavy falls of rain will overflow into the outer receiver.

The evaporation-gauge should be at least six feet square and two feet deep, as the water in smaller gauges gets unduly heated and they register too much. As an area of $\frac{1}{100}$ of an acre has been adopted for both rain-gauges and percolation-gauges, it would be well to adopt the same area for evaporation-gauges, which might be rectangular (say 7 feet 3 inches by 6 feet, or 6 feet $7\frac{1}{3}$ inches square), or circular (7 feet $5\frac{1}{4}$ inches in diameter); but the precise area is of no consequence, if sufficiently large. The water should be kept up to within three or four inches of the top, the gauge being sunk in the ground to about this height, so that the water is usually nearly level with the surface of the ground. The amount of evaporation is determined by the decrease in the height of the water when no rain has fallen, and when rain has fallen by adding the decrease in height to, or subtracting the increase in height from, the depth of rain. A rain-gauge is therefore a necessary adjunct to an evaporation-gauge.

The percolation-gauge may be of any size from 18 inches in diameter and from three feet to six in depth, as at Nash Mills. At Lea Bridge Mr. Greaves used gauges three feet square, and at Rothamsted Messrs. Lawes and Gilbert are experimenting with

* This is the size recommended by Mr. G. J. Symons, F.R.S.

them $\frac{1}{1000}$ of an acre in area. The gauge should be filled with the ordinary soil of the district, and should have grass growing on its surface; its rim should project about two inches above the surface of the ground; and a pipe from the bottom should lead to a collecting vessel, the top of which should of course be below the bottom of the gauge. For experimental purposes percolation-gauges may be filled with any material; in a chalk district, for instance, it would be well to have one filled with chalk, in a sandstone district with sandstone, etc., grass being grown on the surface, but such gauges in every case should be supplemental to the gauge which is filled with the soil which is most prevalent in the district, and by which in most cases it will probably be surrounded. At Rothamsted the soil was left undisturbed, the gauges being built up around them, and for the special purpose of the investigation vegetation is not allowed to grow on the surface.

The three gauges—for rainfall, evaporation, and percolation—should be read daily at 9 a.m., and their records should be entered to the previous day, as in all rainfall investigations. If, in addition, a river flowing by were gauged, and the height of water in a well at some distance from the river were measured daily, or even monthly, very valuable information which we do not as yet possess would in course of time be obtained. Such an investigation might with great advantage be undertaken by the Hertfordshire County Council.

Rainfall observations have been carried on in Hertfordshire since the year 1833, and I have elsewhere shown that the mean rainfall for the whole county for the 50 years 1840–79, as deduced from observations taken at a varying number of stations, has been between 26 and 26½ inches.* The mean rainfall in Hertfordshire for each year during this period is shown in the accompanying table (p. 139) which is compiled from continuous observations taken at the following stations:—Nash Mills, Hemel Hempstead,† 1840–90; Hitchin and Royston, 1850–90; Rothamsted, Harpenden, 1853–90; Berkhamsted, 1855–90; Gorhambury, St. Albans, and Bayfordbury, Hertford, 1860–90; and Much Hadham, 1865–90; each year being from 1st October to 30th September, and the years being divided into summer and winter halves.

If we assume the mean rainfall in Hertfordshire for the half-century to be 26¼ inches, we shall probably be as near as possible to the truth.

But the rainfall in this part of England has been considerably greater during the last 50 years of the present century than it was during the first 40 years, and therefore this is too high a mean for the county for the century, the true mean being a little under 25 inches. This determination has been arrived at by combining with

* 'Trans. Herts Nat. Hist. Soc.,' Vol. VI, p. 82.

† This being the only rainfall station in Hertfordshire during the decade 1840–50, and having a rainfall 5 per cent. in excess of the mean fall in the county, the values from it for this decade have been reduced by this amount in order to give the true mean as nearly as possible.

Mean Rainfall in Hertfordshire for the last Half-century.

Year.	Winter. Oct.–March.		Summer. April.–Sept.		Year. Oct.–Sept.	
	Inches.	Ratio.	Inches.	Ratio.	Inches.	Ratio.
1840–41	9·81	75	16·10	122	25·91	99
41–42	15·73	121	11·54	88	27·27	104
42–43	12·79	98	13·34	101	26·13	100
43–44	14·64	112	7·66	58	22·30	85
44–45	12·45	95	10·99	83	23·44	89
45–46	13·23	101	10·93	83	24·16	92
46–47	12·28	94	10·75	82	23·03	88
47–48	15·05	115	12·35	94	27·40	105
48–49	12·82	98	13·21	100	26·03	99
49–50	8·15	62	11·23	85	19·38	74
1850–51	13·20	101	9·76	74	22·96	88
51–52	10·29	79	17·53	134	27·82	106
52–53	17·61	135	15·42	117	33·03	126
53–54	8·78	67	9·51	72	18·29	70
54–55	9·43	72	13·08	100	22·51	86
55–56	13·80	106	14·98	114	28·78	110
56–57	11·73	90	14·79	112	26·52	101
57–58	11·83	91	13·04	99	24·87	95
58–59	9·12	70	16·58	126	25·70	98
59–60	15·15	116	19·85	151	35·00	134
1860–61	11·81	90	9·96	75	21·77	83
61–62	12·16	93	13·81	105	25·97	99
62–63	11·08	85	12·13	92	23·21	89
63–64	10·63	81	8·47	64	19·10	73
64–65	11·74	90	12·46	95	24·20	92
65–66	19·48	150	16·21	123	35·69	136
66–67	13·10	100	14·97	114	28·07	107
67–68	11·21	86	10·07	76	21·28	81
68–69	16·04	123	11·88	90	27·92	107
69–70	12·68	97	7·52	57	20·20	77
1870–71	12·06	92	15·57	119	27·63	106
71–72	11·21	86	13·84	105	25·05	96
72–73	20·78	159	11·42	87	32·20	123
73–74	9·59	73	10·63	81	20·22	77
74–75	11·54	88	15·78	120	27·32	104
75–76	17·01	130	13·61	104	30·62	117
76–77	19·47	150	14·32	109	33·79	129
77–78	12·39	95	17·97	137	30·36	116
78–79	14·51	111	22·69	173	37·20	142
79–80	6·14	47	15·49	118	21·63	82
1880–81	17·68	136	13·03	99	30·71	117
81–82	14·06	108	14·37	109	28·43	109
82–83	20·35	156	13·76	105	34·11	130
83–84	11·58	89	9·92	75	21·50	82
84–85	12·65	97	13·56	103	26·21	100
85–86	14·58	112	11·36	86	25·94	99
86–87	15·05	115	9·10	69	24·15	92
87–88	11·37	87	13·55	103	24·92	95
88–89	11·31	87	16·29	124	27·60	105
89–90	11·32	87	11·34	86	22·66	87
Mean	13·05	100	13·15	100	26·20	100

the Hertfordshire observations the record at Sunbury in Middlesex, compiled from observations taken continuously from Sept. 1796 to Sept. 1839.* For the 6 years, Oct. 1833 to Sept. 1839, the rainfall in Hertfordshire, deduced from the observations taken at Nash Mills during this period, was 10½ per cent. greater than at Sunbury, and therefore, in order to arrive approximately at the mean rainfall in Hertfordshire from Oct. 1800 to Sept. 1833, the Sunbury record has been increased 10½ per cent. By this method the earlier portion of the following table, showing approximately the mean annual rainfall in Hertfordshire in decades for the last 90 years, has been compiled.

Computed Mean Rainfall in Hertfordshire for the present Century.

Decade.	Winter. Oct.–March.		Summer. April–Sept.		Year. Oct.–Sept.	
	Inches.	Ratio.	Inches.	Ratio.	Inches.	Ratio.
1800–10	11·417	93	12·139	96	23·556	95
1810–20	11·359	93	11·359	90	22·718	91
1820–30	11·567	94	13·726	109	25·293	102
1830–40	10·876	88	10·549	84	21·425	86
1840–50	12·695	103	11·810	93	24·505	98
1850–60	12·094	99	14·454	115	26·548	107
1860–70	12·993	106	11·748	93	24·741	99
1870–80	13·470	110	15·132	120	28·602	115
1880–90	13·995	114	12·628	100	26·623	107
Mean	12·274	100	12·616	100	24·890	100

Assuming that 25 inches is our approximate mean annual rainfall, although the secular decrease in the rainfall of the globe should not be totally ignored, we may for all practical purposes accept with confidence the conclusions which Mr. Symons has arrived at with regard to the probable extreme variation. "There are now," he said a few years ago,† "hundreds of records of rainfall in this country of thirty or more years each, and in a very large proportion of them it will be found that the following proportions will be within 7 per cent. of the truth:—

Wettest year, 45 per cent. more than the average.
Driest year, 33 per cent. less than the average.
Driest two consecutive years, 26 per cent. less than the average.
Driest three consecutive years, 21 per cent. less than the average."

* 'Meteorological Register kept at Sunbury Vicarage, Middlesex, by the Rev. James Cowe, M.A., 1795 to 1839.' London, 1889. I have examined several old records of the rainfall in the neighbourhood of London, and all show a less amount of rain in the earlier than in the latter part of this century, and in general corroborate Mr. Cowe's observations.

† 'Water-Supply and Distribution,' pp. 41, 42. (International Health Exhibition. Conferences.)

In questions relating to water-supply we have only to consider the average rainfall so far as it enables us to estimate the probable minimum, upon which we can alone rely; not necessarily in every case the minimum of a single year, but rather in most instances that of a short series of years, such as three; hence the value of these rules, the last especially.

The mean rainfall at our oldest Hertfordshire station, Nash Mills, for the last half-century, has been 27·90 inches per annum. Taking each year as from the 1st of October to the 30th of September (a winter and a summer half), the driest year was 1863–64 with 17·66 inches; the driest two consecutive years were 1853–55 with an average of 20·55 inches; and the driest three consecutive years were 1862–65 with an average of 20·87 inches. Applying the rules of Mr. Symons, the figures should be within 7 per cent. of 18½ ins., 20½ ins., and 22 ins., whereas they are really within 4 per cent. of these amounts, a remarkably close approximation. These rules strictly apply only to the rainfall at a single station, and in applying them to that of our county we shall, I think, be safe in ignoring the deviation allowed of 7 per cent., as an excess of that amount at some stations will probably be compensated for by a defect at other stations. With a mean annual rainfall of 25 inches we may therefore have a single year with only 16¾ inches of rain; two years in succession with an average of 18½ inches; and three years in succession with an average of 19¾ inches.

I am not aware that any observations on evaporation from water-surfaces that can be relied upon have been made in Hertfordshire. At Lea Bridge, only a short distance from the south-eastern boundary of our county, experiments were made by Mr. Charles Greaves during the 14 years 1860–73, the result from the records of a gauge 3 feet square and 1 foot deep, floating on a running stream, giving an evaporation of 20·61 inches per annum, with a rainfall during the same period of 25·72 inches, the rainfall thus exceeding the evaporation by 5·11 inches. At Strathfield Turgiss, in Hampshire, for the 14 years 1870–83, the Rev. C. H. Griffith observed the evaporation from a tank 6 feet square and 2 feet deep sunk in the ground, and determined the mean to be 18·03 inches per annum, with a rainfall of 25·85 inches, the rainfall thus exceeding the evaporation by 7·82 inches. Mr. G. J. Symons has given, for the five years 1885–89, the results of observations of evaporation from the same tank in his garden in Camden Square, London, the tank having been removed there from Strathfield Turgiss, and he has found the mean to be 14·54 inches out of a rainfall of 24·89 inches, being a difference of 10·35 inches. These are the most satisfactory observations of evaporation from water-surfaces which have been made in this country, and the difference between their results may be accounted for. We have seen that the greater the circulation of wind—the greater the amount of air passing over water or over moist land—the greater will be the evaporation, and, as Mr. Symons cautiously observes: "in the middle of a stream," the position of Mr. Greaves' gauge, "*it is said*

that there is always a breeze."* Again, the altered position of Mr. Griffith's gauge, from open country at Strathfield Turgiss to a garden partially sheltered from the wind by houses, and with the less clear atmosphere of London, fully accounts for the smaller amount of evaporation arrived at by Mr. Symons. If we assume, and I think we may do so, that one inch, at least, of the lessened evaporation is due to the difference in the clearness of the atmosphere, we have the following results for the South of England with an average rainfall of about 25½ inches :—Annual evaporation from still water on land in a sheltered situation, 15½ inches; from the same in the open country, 18 inches; from still water on the surface of a flowing stream, 20½ inches; while from a flowing river itself the evaporation is probably rather greater than this.

These figures will, I think, represent approximately the evaporation from our sheltered ponds, our lakes and reservoirs, and our flowing streams.

The average evaporation from the surface of the ground can only be deduced from the difference between the rainfall and the percolation. From observations of a percolation-gauge $\frac{1}{1000}$ of an acre in area and 3 feet in depth, at Rothamsted, during the 20 years September, 1870, to August, 1890, Messrs. Lawes and Gilbert determined the average annual percolation to be 13·61 inches out of a rainfall of 30·29 inches, showing an evaporation of 16·68 inches, the surface of the ground being kept free from vegetation. At Lea Bridge, during the 22 years Oct. 1851 to Sept. 1873, Mr. Greaves determined the average annual percolation through a gauge 3 feet square and 3 feet deep to be 6·85 inches out of a rainfall of 25·76 inches, leaving 18·91 inches to be accounted for by evaporation and absorption by the grass growing on the surface. At Nash Mills during the 44 years, October, 1840, to September, 1884, Messrs. Dickinson and Co.'s percolation-gauge,† 18 inches in diameter and 3 feet in depth, gave an average annual percolation of 6·94 inches out of 28·18 inches of rain, 21·24 inches being evaporated and absorbed by the grass growing on the surface. In each instance I give the results only of the percolation through gauges filled with the ordinary soil of the district. Through chalk and sand the percolation is greater.

Taking into consideration the difference in the rainfall, in the situation of the gauges, and in their construction, the results do not, I think, show any greater divergence than should be expected.‡

Much depends upon how the rain falls. A heavy fall after a dry period will not percolate more than a few inches, and if another dry period succeed, the moisture will be rapidly drawn up to the surface and evaporated. On the other hand, a continued drizzling rain,

* 'British Rainfall,' 1889, p. 40.

† Still in operation, but no more-recent results have been published.

‡ The results of experiments on evaporation at Strathfield Turgiss and Camden Square are taken from 'British Rainfall,' 1886–89, and those of experiments on evaporation and percolation at Lea Bridge, and on percolation at Nash Mills and Rothamsted, from several papers and discussions in the 'Proceedings of the Institution of Civil Engineers,' 1843–1891.

with a humid atmosphere, will nearly all percolate beyond the reach of evaporation. At Nash Mills during the winter of 1858–59, 9·64 inches of rain fell, of which only 0·09 inch, or less than 1 per cent., percolated through three feet of soil, while during the winter of 1879–80 only 5·84 inches of rain fell, of which 2·79 inches, or 48 per cent., percolated. Again, very much more rain percolates during the six winter months than during the six summer months, the difference being chiefly due to the much larger amount absorbed by vegetation in summer than in winter. With an average annual rainfall at Nash Mills of about 28 inches, the percolation in winter averages 46 per cent. of the rainfall, and in summer about 4 per cent. With this rainfall and percentage of percolation, if 10 inches of rain fell in the winter and 18 in the summer, the percolation would be 5·32 inches, while if 18 inches fell in the winter and 10 in the summer, it would be 8·68 inches. The difference would really be much greater than this, for in a wet winter the percentage of percolation would on the average be much greater than in a dry one, and in a dry summer it would probably be *nil*.

If we can rely upon the experiments at Strathfield Turgiss, Nash Mills, and Lea Bridge, of which I have given some of the chief results, as affording a fair average, it follows that out of a mean rainfall of 25½ inches, the evaporation from a water-surface is 18 inches, or 70 per cent. of the rainfall; and out of a mean rainfall of 27¼ inches there is evaporated from the surface of the ground or absorbed by vegetation, 20 inches, or 73½ per cent. of the rainfall, the percolation being 7¼ inches, or 26½ per cent. of the rainfall. The evaporation from the ground thus appears to be little more than that from water, but this is owing to its frequent dryness. If the ground covered by vegetation were always moist, the evaporation would be doubled, but this is practically an impossibility, as it would then greatly exceed the rainfall. It is probable that an appreciable portion of the water evaporated returns to the earth in the form of dew without being measured by the rain-gauge; but, as we have only to deal with the amount which percolates through the soil, this question need not be discussed further. A small portion of the water which percolates into the Chalk, also, must be entirely lost to us every year, sinking through the comparatively retentive beds which form the base of this formation, and eventually arriving at the plane of temperature of the boiling-point of water, which, as already mentioned, is constantly approaching the centre of the earth.

Assuming, as we are justified in doing, that a nearly constant quantity of water is evaporated from the surface of the ground or absorbed by vegetation, and taking the mean rainfall for Hertfordshire as 26¼ inches, being that of the last half-century, we may infer that 6¼ inches percolates through 3 feet of soil. It is then usually assumed to be out of the reach of evaporation and vegetation, but this assumption is not fully warranted. Professor Ansted has expressed his opinion that there is no practical limit to the capillary action of chalk, and he has made experiments which have

shown that water will rise in it by capillary action at least 16 feet. The roots of many trees and of some more lowly plants descend more than 3 feet through the soil, and their tips or spongioles are powerful absorbers of moisture. It has been shown that an oak tree will absorb during the whole period of its summer growth more than eight times the amount of water that falls on the area covered by it, the excess being drawn up by the roots from great depths.* It must, therefore, I think, be conceded that an appreciable quantity of the rain which falls will rise from a greater depth than three feet and be evaporated; how much we do not know, but if we take it at only a quarter of an inch,† it will leave an available supply for our underground reservoir of 6 inches per annum on the average of a long series of years. This is the amount the Commissioners on the Pollution of Rivers estimated in 1874 might be relied upon throughout the exposed chalk area in the river-basin of the Thames. But rainfall is exceedingly variable, and percolation is still more so, the results of experiments at Nash Mills and Lea Bridge showing that for six years in succession we may have to rely upon only $4\frac{3}{4}$ inches of percolation per annum, for five years upon $4\frac{1}{2}$ inches, for four years upon 4 inches, and for three years upon 3 inches.

This part of my subject has, I fear, already extended to undue length; but the erroneous conclusions which have been arrived at by neglecting it, or by lack of knowledge of the relation existing between rainfall, evaporation, and percolation (and also of the amount of available area for percolation), show that it is necessary to devote some attention to its consideration. For instance, Mr. S. C. Homersham, in a Report to the Directors of the London (Watford) Spring-Water Company, in the year 1850, made the following astounding statement:—"The area of land sloping towards Watford, and consisting for the most part of steep chalk hills,‡ embraces more than 1200 square miles, and calculating that only a depth of 20 inches of rain per annum falls in this locality, at least one-half, or 10 inches, may be considered as reaching the lower fissures. . . . This," he added, "is equal to supply the immense quantity of 408 millions of gallons per day, for every day in the year, which at presents finds a vent and is discharged along the coast."

The fact is that the area of land sloping towards Watford scarcely embraces 150 square miles, of which not more than 100 are occupied by permeable beds,—either chalk or chalk capped by gravel,—and moreover with 20 or even 25 inches of rain not more than 5 inches would be likely to percolate into "the lower fissures," so that instead of 408 millions of gallons per day, the amount would probably be

* See 'Nature,' vol. vii, p. 118.

† This must be much under the mark.

‡ In the same year, in a discussion on one of Mr. Clutterbuck's papers ('Proc. Inst. Civ. Eng.,' vol. ix, p. 162) Mr. Homersham spoke of hills "from 800 to 1000 feet in height around and sloping towards Watford." These hills are barely half this height, and only from 100 to 300 feet higher than the valley of the Colne.

scarcely 20 millions, which is very little, if any, more than the Colne, a few years before this, had been found to carry away daily,* the amount available for discharge along the coast, if it could get as far, thus being reduced to an almost inappreciable quantity. The absurdity of Mr. Homersham's conclusion is manifest when we consider that it implies a flow of water under Watford, and in some inexplicable manner into the sea, equal to the mean flow of the Thames about midway between Staines and Teddington.

We have next to follow, as nearly as we can, the course of the water which percolates into the chalk. It descends to the plane of saturation with very varying degrees of rapidity; where the chalk is compact, the percolation is exceedingly slow; where it is fissured or there are "pipes" filled with loose gravel which have been formed by the dissolution of the chalk in the manner already explained, it may be very rapid. In our Upper Chalk district the water on its way down encounters nearly horizontal bands of flints loosely aggregated together, along which it flows much more readily than in the compact chalk. It will therefore tend to flow along the plane of dip of the strata, which, in the valleys of the Lea and Colne, is from north-west to south-east at a slight angle from the horizontal.

From sections exposed in our chalk-pits we know that "pipes" are more or less vertical, and therefore while some of the water is carried in the direction of dip, which is nearly horizontal, some of it rapidly sinks in a nearly vertical direction, and as the water flows along the plane of dip it will be constantly encountering these pipes and be carried down in them. Towards its base the Chalk is more retentive of water and less fissured than it is throughout the greater part of its mass, so that the percolation becomes gradually slower, or rather would do so if the rock were not here, when in a natural condition, already fully saturated. Below the Chalk the great comparatively-impervious mass of the Gault Clay holds up the water as in a but very slightly porous basin; in fact we may, for all practical purposes, altogether neglect its porosity, and consider that the water in our Chalk is retained naturally by the Chalk Marl and Gault at its base as efficiently as the water is retained artificially by the bed of a well-made reservoir.†

The term "underground reservoir," as applied to the water in the Chalk, does not convey a clear idea of the actual state of saturated rocks. We naturally picture a reservoir as a sheet of water which maintains a horizontal surface alike when it is added to or taken from, but chalk offers a very considerable frictional resistance to the flow of water in it, and it is a long time before water added at any one spot percolates laterally through it so as to assume a horizontal surface; in fact it very seldom if ever does so for any great distance. The resistance chalk thus affords to the passage of

* Stephenson's 'Report to the London and Westminster Water Company,' 1840, p. 12.

† I have omitted any reference to the Palæozoic rocks under the Chalk, having previously treated of them in their relation to the water-bearing strata. 'Trans. Watford Nat. Hist. Soc.,' Vol. II, p. 241.

water causes the plane of saturation to assume an inclination of from 24 feet to the mile at the higher ground to 12 feet to the mile at the lower, where the water issues out in springs, on the surface of the ground, in pools, or in the beds of our rivers. The greater the rainfall, the steeper will be the inclination of this plane; the greater the amount of water abstracted by pumping from considerable depths, the steeper it will be; but in the former case it will be raised towards the surface of the higher ground, as it is in winter by the water percolating into it faster than it can flow through it laterally to the rivers and springs, and in the latter it will be lowered towards the point of abstraction.

In this, as in all Chalk districts, the rivers are supplied by springs issuing out of the chalk where the inclination of the plane of saturation is greater than the inclination of the surface of the ground, when this is caused by an excess of water; and the rivers on the Chalk, if no impermeable strata intervene, only flow over the surface when their beds cut into this plane, for if it were below their beds the water would sink into the chalk and disappear.

Near the sea the natural outlet for the surplus water in the chalk is undoubtedly along the cliffs and under the bed of the sea itself; but inland, as here, the natural outlet is in the springs which supply the rivers. These are not only at the sources of the rivers, but they are also of frequent occurrence along their beds, the flow of the rivers thus being constantly augmented without the aid of any tributary streamlets. These springs are due to the overflow of the subterranean reservoir, and they are therefore an absolute measure of the amount of rain which percolates into this reservoir, when there is no leakage and its resources are not artificially drawn upon. When, therefore, there is an artificial abstraction of water, as from wells, there must be a smaller supply for the rivers to the extent of that abstraction.

When the Colne Valley Water Company was projected, it was stated that the well would be steined or made water-tight for a sufficient distance downwards from the surface of the ground to ensure that no water would be abstracted from the Colne. Let us see how far this precaution is of any avail. Suppose that any of us had an underground tank supplied by the rain falling on the roof of our house, with an outlet near the top, from which, when the tank was nearly full, a stream of water flowed through our garden, keeping our ferns and rock-plants fresh and green throughout the summer, except in very dry seasons, and our neighbour said that he should like some of the water for his own garden, and if we would let him take as much as he wanted, he would take it without depriving our garden of any, for he would merely put a pump into our tank and take care that no water came into the pump except from the bottom of the tank, should we let him do it? We should, I think, rather say: "No, you may take as much water as you like from the stream which flows through our garden, after it has passed our rock-work, but you shall not pump it from our tank."

The two cases are similar.* The Colne Valley Water Company was allowed to erect a pumping-station, put one or more pumps into the reservoir in the Chalk from the overflow of which the Rivers Colne and Ver derive their supply of water, and to pump any amount of water from the bottom, or near the bottom of this reservoir, on the simple assurance that no water should be taken from the top, or near the top of it. This is not a single case, the farce has been enacted over and over again, but I think that the knowledge of the underground circulation of water has spread to such an extent that very few would now say to their neighbour: "You may draw as much water from the bottom of my tank as you like, if you will let me have all that overflows from the top."

It has been argued that there is a leakage from our underground reservoir—that some of the water flows under London and into the sea—and that by pumping we are reducing this amount; but, again to borrow our homely illustration, should we be any more inclined to let our neighbour pump the water out of our tank if we knew that there was a leakage, and that, when the tank was full, the overflow did not represent quite all the water which flowed into it?

With regard, however, to this possible leakage, it should be borne in mind that the main question of the availability of underground water for a water-supply—whether from our surface-springs or deep wells—is one of time. The natural leakage under London must be slow, for it is well known that the Chalk, under the great mass of Tertiary strata, is much more compact than it is on its outcrop, and therefore must offer here a much greater resistance to the passage of water through it. This is due, partly to the pressure of the London Clay and Lower Tertiaries, and partly to the fact that the chalk under these impervious beds is not subject to dissolution by the percolation of water from the surface. In our chalk-pits we never see "pipes," which are thus caused, when there is a thick bed of clay over the chalk. The leakage would be increased by water being pumped from great depths under London itself, and doubtless by this means channels have been formed in the Chalk under the London Clay. If water be *continuously* withdrawn from our underground store by these channels more rapidly than it is supplied by percolation, the water-level must be lowered, and the overflow which feeds our rivers must be lessened, and in course of time cease altogether in dry seasons. Although the *natural* leakage must be so slow that it cannot prejudicially affect the flow of our streams, it is very different when water is *artificially* abstracted from the lower part of our valleys by exhaustive pumping, and is conveyed quite away from their drainage-area, or when channels are formed by pumping at a distance, as in London. By such

* A filter, however, affords a more precise parallel to our reservoir of saturated chalk, but the only difference between it and a tank which affects the argument is one of time. No one would contend that water could be drawn from the bottom of a filter without the amount of water in it being reduced, and the surface consequently lowered, although some time would be taken by the water to filter through. A similar illustration—that of a tank—has been used by Sir John Hawkshaw and Dr. John Evans. See 'Proc. Inst. Civ. Eng.,' vol. cv. (1891), pp. 57 and 62.

means the plane of saturation is lowered, and the Chalk is gradually dried throughout its whole extent. At each deep boring from which a large quantity of water is being pumped, this plane forms an inverted cone which gradually enlarges, and in course of time the present sources of our rivers must be affected by the water flowing underground to supply the void thus caused, instead of over the surface. Every million gallons of water thus drawn from the chalk carries with it in solution, on the average, a ton and a quarter of the chalk through which it has percolated, giving an additional storage-room for 110 gallons of water. This accounts for the yield of a well increasing for a certain time until the maximum of permeability is reached, but it implies a more rapid lowering of the plane of saturation, and thus increases the evil effects of exhaustive pumping.

That there are channels in the Chalk through which water flows with comparative freedom, apart from the more or less vertical "pipes" and slightly-inclined layers of flints, does not admit of doubt. They are frequently met with in well-sinking, etc., when tapped the water in them flooding the works, and the determination of the probable direction in which they convey the water is of much importance. In most cases we cannot ascertain it, but I think we have some grounds for inferring the usual direction of such channels near the surface. The plane of saturation conforms pretty nearly to the form of the ground, sloping down under our hills transversely to the rivers which flow between them, but at a less inclination than that of the surface of the ground. At the bottom of the valleys in the Chalk, when rivers flow through them, the longitudinal inclination must be as great as or greater than that of the rivers. The general direction of the flow of water underground is therefore the same as that above ground, for the water must flow from the higher to the lower level. This is well shown in bournes, or streams which only flow after very wet winters, the water in them sometimes disappearing for some distance, and re-appearing with undiminished flow. Even in the River Colne I have seen a considerable volume of water entirely disappear, and re-appear lower down the valley. Such cases show that there must be underground channels which follow the general course of the streams on the surface. This, we may infer, is most probably the usual direction in which water flows immediately below the surface of the ground, but this flow is not from the bottom but from near the top of our underground reservoir, and therefore is rather an underground overflow than a leakage, and could not unduly drain it.

But, as it has already been pointed out, there must also be a considerable flow of water in the layers of flints in the Upper Chalk, and in Hertfordshire the inclination of these layers is from north-west to south-east at a comparatively high (though really low) angle in the north-west, and gradually approaching horizontality in the south-east. Part of the catchment-basin of the Colne is directly north-west of the lower portion of the valley of the Lea north of London, and therefore much of the rain which falls within the

Colne watershed, and percolates to these layers of flints, must be carried along them beneath the catchment-basin of the Lea; and I think there can be little doubt as to the correctness of the conclusion which Mr. R. W. Mylne arrived at from a long and careful study of the underground waters of this district, in his capacity of Engineer to the New River Company, that the water absorbed in the swallow-holes at Potterells is completely lost to the Colne, being conveyed underground to the lower portion of the valley of the Lea. It was his opinion that the Amwell Spring and other springs in its neighbourhood were thus fed, but to be certain of this we require more conclusive evidence than he has adduced. He was convinced that "no large supply of underground water can be met with, within a moderate radius of London, without diminishing the minimum, or dry-weather, flow of the streams."*

The point of practical interest to us is that the pumping of water from great depths in the valley of the Lea between Hoddesdon and Tottenham may drain the Colne and its tributaries almost as much as the Lea and its tributaries. At New Southgate, near Barnet, the nearest point to the head of the Colne at which the New River Company has a pumping-station, nearly all the water drawn is probably derived from the rainfall in the upper portion of the Colne valley, most of which, as we have seen, disappears from the surface at Potterells and in numerous swallow-holes in the bed of the river above that point. This question, however, properly belongs to the next division of our subject, the Water-supply of London.

The configuration of London and its suburbs has been mainly determined by the presence of the water-bearing alluvial gravels which rest upon the London Clay in the valley of the Thames. Rain falling on the surface of the ground permeates and saturates these gravels, being held up by the clay, so that it was at one time only necessary to sink a well a few feet in depth in order to obtain a supply of water. Where, also, the gravel was cut through down to the London Clay by shallow valleys, springs then issued forth, whose waters are said to have been, in the reign of Henry the Second, "sweet, salubrious, and clear." With an increasing population, and with no drainage but that which cess-pools afforded, these sources of supply gradually became contaminated, but were used, with very prejudicial effects, after they had ceased to be sufficient, and recourse to outside sources had become absolutely necessary.

Even as early as the year 1236 "the citizens were forced to seek sweet waters abroad," and water was conveyed "from the town of Tie Burn [Tyburn] by pipes of lead into the City," but most of the water required for domestic purposes was brought in buckets from the Thames.

In 1582, and for 240 years afterwards, water was pumped from the Thames by water-wheels worked by the tides in the arches of old London Bridge, and conveyed by pipes first to a small area in the City and in course of time to all parts of London.

* See 'Report Brit. Assoc. for 1890,' p. 353.

About a quarter of a century after this, when only two of the nineteen arches of old London Bridge were occupied by water-wheels, a number eventually increased to five, the Citizens of London, by Act of Parliament made in the third year of the reign of James the First, "had free libertie given unto them and were enabled to bring a ffresh streame of runing water to the North part of the said Citty of London from the springs of Chadwell and Amwell, and other springs in the Countie of Hertford, and not far from the said springs." For some years this scheme remained in abeyance, but in 1608 Sir Hugh Myddleton commenced to carry it out at his own cost,* and after five years' labour, and with considerable assistance in funds from the King, the gigantic work was completed, and the water from the Chadwell and Amwell springs, diverted from the River Lea, flowed into London in a wooden conduit called the New River, then 40 miles in length, but now reduced to 28 miles, and no longer constructed of wood. A brief account of Sir Hugh Myddleton's undertaking will be found in our "Transactions,"† and I need only mention here that when, in 1619, the New River Company was formed, there could have been no intention of adding to the supply which these springs and the River Lea afforded by boring into the Chalk.

The only other Company taking water from the River Lea, and from borings in the Lea Valley, is the East London Waterworks Company, which was established in 1807, and in the following year purchased the Shadwell waterworks, by which East London had been supplied with water since 1669, and the West Ham waterworks, by which, from 1747, water had been pumped from a branch of the Lea. This Company is authorised to take 10 million gallons daily from the Thames.

The Chelsea waterworks were established in 1723; the Lambeth in 1785; the Grand Junction in 1798 (then a department of the Grand Junction Canal Company); the West Middlesex in 1806; and in 1845 the Southwark and Vauxhall Waterworks Company was formed by the amalgamation of the Southwark, which had existed from 1771, with the Vauxhall, dating from 1804. All these Companies take their supply of water from the Thames, the maximum they can draw being 120 million gallons daily.

There is one other London Water Company, the Kent, incorporated in 1809 to purchase the Ravensbourne waterworks, which had been established in 1701 to supply water from the river of that name. In 1857 the Company sunk a well in the Chalk, at Deptford, and five years later abandoned the Ravensbourne, which had become polluted, since which time the whole supply has been derived from deep wells in the Chalk, now ten in number.

Previously to 1852 the Thames Companies took their supply of water from the tidal portion of the river; but in that year there was passed a very important Act of Parliament, known shortly as the Metropolis Water Act, 1852. Its principal provisions are that

* He was knighted on completion of the work.

† 'Trans. Herts. Nat. Hist Soc.,' Vol. III, p. lxix.

from the year 1855 no Company was to take water from the tidal portion of the Thames, that all river water was to be efficiently filtered, and that there were to be no uncovered reservoirs for domestic supply within five miles of St. Paul's, unless the water were efficiently filtered after leaving the reservoir. The Thames Companies removed their intakes to above Teddington Lock within the specified time, and they have taken even more efficient measures to ensure a pure supply of water to the Metropolis than they are compelled to do by this and other Acts of Parliament.*

About 165 million gallons of water are now supplied to London daily, 50 per cent. being supplied by the five Thames Companies, 6 per cent. by the Kent Company, and 44 per cent. by the New River and East London Companies. Of the 72½ million gallons thus taken from the Valley of the Lea by these two companies,† about 60 million gallons are taken from the river itself, and the rest from springs and wells, in what relative proportion we do not know, but probably at least 10 million gallons are pumped daily from the Chalk. These companies, moreover, are frequently making new wells and headings, and adding to their engine-power, so that the draught upon our underground supply is constantly increasing. They have now about twenty deep wells in the valley of the Lea. To the amount they abstract, also, must be added that required by our own resident population, and if we add the 12 million gallons daily taken from the Chalk by the Kent Company, and the amount pumped in London by brewers, etc., the drain upon the water in the Chalk must be very great.

It has long been known that, owing to the large amount of water abstracted by pumping, the water-level under London is gradually sinking, the rate of depression varying from one foot to two feet per annum.

In the year 1821 or 1822 the water-level in a well in the east of London stood at exactly Trinity high-water mark, or 12½ feet above our present Ordnance Datum. In 1851 its average height was 43 feet below Ordnance Datum, and in 1881 it was about 105 feet below, having thus been lowered 117 feet in sixty years, or at the rate of 2 feet per annum. It is now therefore most probably at least 20 feet lower, for the abstraction of water goes on at an increasing rate. A depression in the plane of saturation at the rate of 200 feet in a century must have serious consequences. In the centre of London, however, the depression is not so great, for the water in the well at the Bank of England has, since the year 1856, suffered a depression averaging only about a foot per annum.

There is ample evidence of the extension of this lowering of the water-level into Hertfordshire. In fact the depression must have been going on from geologic times to the present day, but it is

* A history of the London Water Companies, and the acts relating to them, will be found in Bolton's 'London Water Supply,' Ed. 2 (1888).

† The quantity taken by the New River Company from the Hampstead and Highgate ponds for watering streets and flushing sewers, about 1000 gallons daily, is so small that it does not affect these figures.

probably more rapid now than at any former period, owing to the natural depression being augmented by artificial means. All our dry chalk valleys have been formed originally by running streams. In some the plane of saturation is still so near the surface that water is seen in them after exceptionally wet periods. Others, now always dry, appear to have had water flowing down them within historic times. The valley immediately to the west of St. Albans is one of these. The Ver has considerably declined in volume within the memory of the present generation, and as far back as the thirteenth century it was known to have been a larger river than it was then, for Matthew Paris states that "the Werlam river," as it was called in his time, "*was once very large*, and flowed about the city [of Verulam]."

The River Colne, above its junction with the Ver, is now a smaller stream than the Ver, although its catchment-basin to that point is larger than that of the Ver. This diminution in its volume is doubtless chiefly due to the whole of the water draining a considerable area above North Mimms being now usually absorbed in swallow-holes in the Chalk at Potterells. The channels through which water is being conveyed away from these swallow-holes must be gradually enlarging, but they owe their *existence* to the lowering of the plane of saturation in the Chalk; or they may even formerly have conveyed water into the river. It is but rarely now that the plane of saturation is so raised that the water flows on through North Mimms Park past the mansion which from its situation seems undoubtedly to have been built to look upon a flowing river, the bed of which is now dry during the greater part of every year, and in some years all the year through.

At one time the whole valley of the Lea in the parish of Wheathampstead, Cussans states in his 'History of Hertfordshire,'* "was one vast lake or mere," fordable at certain places, "as at Batford, Pickford, and Mereford, now called Marford. At its narrowest part . . . it was spanned by a bridge, over which passed, and still passes, the road from St. Albans to the North." It contained two islands, and "terminated at Water End, in the adjoining parish of Sandridge." He also refers† to a sketch in Chauncy of Littlecourt, between Corneybury and Buntingford, showing the River Rib, which flows before the house. It is represented, he says, "as being nearly on a level with the banks, and three figures appear fishing in the stream." Now "the bed of the river is quite dry for the greater part of the year," and fishing is out of the question, though "forty [now nearly sixty] years ago the river contained an abundance of pike, roach, perch, and trout." There are vestiges and records of several water-mills on this river, for which the supply of water is now utterly inadequate.

To come to more recent times, it may be stated that for the last ten or twenty years or longer, the water-power in our rivers, both the Colne and the Lea and their tributaries, has been declining, so

* "Hundred of Dacorum," p. 326.
† "Hundred of Edwinstree," p. 83.

that a smaller number of stones can now be worked than formerly, and many millers are obliged to put down steam-engines. Even within the last ten years, the Hon. A. H. Holland-Hibbert informs me, the level of the water in the Colne at Munden has gradually fallen to the extent of four or five inches. Watercress-growers are complaining of shortness of water, and it seems as if one of the most important industries of Hertfordshire, if not *the* most important, were seriously threatened with extinction. Wells are running dry, and have to be deepened so that they may continue to yield a supply. This has been the case at the Watford and also at the Berkhamsted waterworks; at the St. Albans waterworks, near Bernard's Heath, the pumps, at one time working under water, have had to be carried down some distance to enable them to draw water at all, and a new pumping-station has been erected in the valley, close to the River Ver, and is now to be extended by an additional bore-hole, by which means an increased amount of water will be, indirectly, drawn from the river; and at the Ware waterworks the water-level has lowered progressively about a foot a year for the last 18 or 20 years.

It may be urged that increased drainage may have had some effect in carrying the water more rapidly off the land, and so permitting less to percolate, but that would augment the flow of our rivers for the time, and of this we have no evidence so far as I am aware. It may very likely, on the other hand, have had the contrary effect, for we do not underdrain the chalk, where percolation is comparatively rapid, but only stiff wet land, where there is scarcely any percolation, and on it the drainage may, by removing water from the surface where it is subject to rapid evaporation, increase the amount which percolates. The main cause of the permanent reduction in our water-level in Hertfordshire in recent years must be the abstraction of water by pumping and the removal of that water to a distance for the supply of London and the district between Watford and London. The water pumped up for our own use will add its quota, but only in the immediate neighbourhood of the wells and borings, for practically all of it is returned into the chalk or sent into our rivers after we have done with it.

It may be objected that, after all, this process of depletion must be very slow, for we have a vast reservoir to draw from. This objection admits of an easy and complete refutation.

Hertfordshire has an area of 633 square miles, about half of which is occupied by permeable strata. The greater part of this area is in the catchment-basin of the Thames, a small portion in the north (about 75 square miles) being in that of the Great Ouse. Of that in the Thames, a very small portion (about 10 square miles) is in the catchment-basin of the Thame in the north-west, and another still smaller portion (about 5 square miles) is in that of the Brent in the south, the bulk, about 543 square miles, being in the catchment-basins of the Colne and Lea. On the east the Lea and its tributaries drain a considerable portion of Essex; on the west the Colne and its tributaries drain a much smaller portion of Bucks.

The source of the Lea is in Beds; the source of the Colne, higher than the point where its waters are usually lost in swallow-holes in the Chalk, is in Middlesex, adding a little to the drainage-areas of these rivers. On the whole, the catchment-basin of the Lea, above the lowest point where the New River and the East London Companies are augmenting their supplies by deep borings, comprises an area of about 430 square miles, and the catchment-basin of the Colne, above the point where it is now proposed to bore for an additional supply of water for London, comprises an area of about 235 square miles, or together 665 square miles, of which about half are occupied by permeable strata. Adding the area drained by a few streams which flow for some distance over the London Clay, but are frequently dry in summer, and when they run lose themselves in swallow-holes in the Chalk, we certainly cannot depend upon a percolable area of more than 400 square miles in the catchment-basins of the Colne and Lea, of which may be assigned about 150 square miles to the Colne and 250 to the Lea.

Three inches of rain sinking into our underground reservoir throughout an area of 400 square miles gives a supply of 17,374½ millions of gallons of water per annum, or rather more than 47½ millions of gallons per diem. The average supply to London is about 30 gallons per head of its population each day, but in very dry weather this is exceeded. In an exceptionally dry series of years the supply from the catchment-basins of the Colne and Lea would therefore suffice for about a million and a half of people, or between one-third and one-fourth the amount required by the five and a half millions or so comprising the population of London and its suburbs. In an average year, or in a sufficiently long series of years to ensure a rainfall closely approximating the average, the supply would be about 95 millions of gallons per day, and would suffice, at 30 gallons per head, for about three millions of people. In neither case, however, would there be any water to spare for the population in the areas of the Colne and Lea river-basins, nor would there be any overflow to feed our rivers. The area required to collect the water supplied to London from the Lea valley, about 72½ million gallons per diem, at 6 inches of percolation per annum, is a little over 300 square miles, so that more water is being withdrawn from the Lea catchment-basin than it is collecting, independently of the amount required for its own resident population. Even if we suppose, as we have already seen is most probably the case, that a considerable portion of the water pumped from the Chalk in the Lea valley is derived from the Colne catchment-basin, the draught upon this extended area will still be greater than the supply, and the result must be that the Chalk will be gradually exhausted of the water it contains, and its plane of saturation lowered year by year. This is what is actually occurring, not only in the valleys of the Colne and Lea, but also in the main valley of the Thames under London, and thus the conclusion at which we have arrived by calculation is confirmed by fact.

Although the exceptional lowness of the underground water-level

at the present time is no doubt greatly due to the small rainfall we have had during the last few years, that cannot account for the gradual reduction in its height during the last twenty years or more. We have seen that for the last half-century the mean rainfall in Hertfordshire has been about 26¼ inches per annum, and the deviation from the mean in each of the five decades comprised in this period has been as follows:—1840–49, 5 per cent. less than the mean; 1850–59, 1½ per cent. less; 1860–69, 1 per cent. less; 1870–79, 5 per cent. more than the mean; and 1880–89, 2½ per cent. more. For the first 30 years of the half-century, therefore, the rainfall was considerably less than the average for the whole period, and for the last 20 years it was considerably more. If we take the last 90 instead of the last 50 years, the increase in the rainfall in recent years is still more striking, as will be seen by referring to the table on p. 140.

The process of depletion is certainly a slow one; but if we let it go on until we are seriously affected by it, when we do stop it, if we can, which is very doubtful, the process of replenishment will be still slower. One inch of rain yields about half a gallon of water over every square foot on which it falls, and, as a cubic foot of chalk in its natural moist state will absorb two gallons of water (one-third of its bulk), it will take a depth of 4 inches of rain to saturate it. Assuming that we can rely upon an average percolation through our ordinary soil of 6 inches of rain per annum, each year's rainfall would saturate 18 inches of the underlying chalk. The Chalk of the London Basin varies in thickness from 620 to upwards of 700 feet. Taking it at only 600 feet, if it were exhausted of the available water it contains, it would require 400 years' rainfall to saturate it again. We have seen that the water-level under London, and in some parts of Hertfordshire, is being lowered at the rate of at least a foot per annum. If this reduction in height were general over our Chalk area, and all pumping from the underground reservoir were stopped, it would be forty years before the rainfall (assuming a percolation of six inches per annum) brought up the water-level to the height it was sixty years ago.

In 1868 a Royal Commission was appointed to enquire into the best means of preventing the pollution of rivers. In their Sixth Report the Commissioners expressed the opinion that the rivers Thames and Lea ought to be abandoned as sources of water-supply for London as early as possible, and that recourse should be had to deep borings in the Chalk for the entire water-supply of the metropolis. To the examination of this report Dr. John Evans devoted a considerable portion of his presidential address to the Geological Society of London in the year 1876, in the course of which he said:

"It can hardly be believed that a proposal such as this, involving the diversion of the whole of the water from the natural springs and streams over an area of not less than 440 square miles (an area larger than that of several English counties), should have been brought forward without the slightest reference to what would be the result

upon this vast extent of country, the inhabitants of which are to be sacrificed to the presumed needs of this over-grown city. It will, I think, come within the province of the geologist to point out not only where spring-water of good quality is to be obtained, but also what will be the effect of its abstraction upon the districts where it now exists in sufficient abundance to overflow into the streams. It will be for him to show what will be the effect of producing 'a void below the level at which the drainage of the country naturally escapes;' how what are now fertile and even irrigated meadows will be converted into arid wastes; how watercress-beds, now of fabulous value, will be brought to the resemblance of newly-mended turnpike-roads; how in such a district all existing wells, many of them already some hundreds of feet in depth, will be dried, and even the canals and navigable rivers become liable to sink and be lost in their beds. And these results would, if the scheme were carried out, not be confined to some single spot, but would extend over hundreds of square miles." *

The recommendation of the Commissioners, so strongly deprecated by Dr. Evans, it need scarcely be said, has not been acted upon, and after the lapse of 20 years we are still drawing the bulk of our supply from the rivers which they regarded as in a hopeless state of pollution. But are we safe in taking this polluted water? Let us see what our water analysts, William Crookes and Profs. Odling and Meymott Tidy, say with regard to the composition and quality of daily samples of the water supplied to London by the seven water companies taking their supplies from these rivers. Take, for example, the Report to the official Water Examiner for March last: in it they say:—"Throughout the month . . . the condition of the water furnished to the metropolis by the companies taking their supply from the Thames and Lea has continued to be unexceptionable." In that for September, again, they speak of the results of their analyses as showing "an unbroken purity of supply, even under the severe conditions consequent on flood and an almost unprecedented rainfall. The marked uniformity in the composition of the various waters . . . . is specially noteworthy. Further, the complete freedom of the numerous samples examined from any trace of suspended matter is to be remarked." These are fair samples of their reports, each of which contains a full analysis of the water supplied by all the companies deriving their supply from the Thames and Lea.† We are as yet, however, unable to detect the living germs of disease by either chemical or microscopical analysis,—at least in the stage in which they occur in water,—and we have no means of preventing their access to the water of these rivers or to the underground reservoir in the Chalk.

There is little probability now of any proposition being brought forward to abandon the Thames and Lea as sources of water-supply; but, as the present supply from all sources is insufficient, under the existing methods of distribution, for the constantly-increasing

* 'Quart. Journ. Geol. Soc.,' vol. xxxii, (Proc.) p. 116.
† The Reports were commenced in December, 1880.

requirements of the metropolis, the London Vestries and the Corporation of London are promoting bills for the purchase of the London water companies and the augmenting of the water-supply by means of additional deep borings in the Chalk at Rickmansworth and Leatherhead. Powers are sought by the London Vestries not only to take water from Rickmansworth, but also "to inspect and investigate the causes of pollutions of rivers in the watershed of the Thames and the Lea, and ther ivers of the adjacent districts, and to cause such pollutions to be removed," with the evident intention of draining the catchment-basin of the Lea to a still further extent than it is now being drained by the New River and East London Companies. The bill of the Corporation of London includes provisions for acquiring the right of taking water within the watershed of the River Lea, and any rights, powers, and privileges of any water company or of any other public authority therein.

It is thus proposed in both these bills to augment the water-supply of London by drawing further upon the resources of our county, already overtaxed. As they are rival schemes we may have a better chance of success in opposing them than we otherwise should have had, and they certainly ought to be opposed.*

This question may seem to have little practical interest to residents at Hitchin and other places in North Herts in the catchment-basin of the Great Ouse; but we cannot be certain that the underground water-level will not be affected even here in course of time; for although the water-parting above ground between the catchment-basins of the Lea and Ouse is to the south of this district, underground it is either immediately under it or to the north, for the water is held up in the Chalk by the Totternhoe Stone, and below that by the Chalk Marl, and still lower, the water which percolates through these rocks is upheld by the Gault Clay, all of which strata crop out in succession to the north. Hitchin is therefore, by reason of these strata dipping to the south, most probably in the hydro-geological basin of the Lea. It may, however, be a long time before the north of Hertfordshire is affected by the withdrawal of water from the Chalk from such a distant point as Hertford or Ware, and I would insist upon nothing further than the assertion that the interests of the whole county, since the institution of the County Councils, are identical. Instead of more water being taken from our county for the supply of London, we ought to endeavour to get the amount now taken reduced, and this can only be done by the New River and East London Water Companies, or the new Authority by which they may be supplanted, being restricted in the amount that may be abstracted, to which amount at present there is no limit.

* Since this was read both bills have been thrown out by the Select Committee appointed to consider them, and this result is in great measure due to the opposition of the Hertfordshire County Council. The resolutions passed at the three meetings of our Society (at St. Albans, Hertford, and Hitchin), at which this question was brought forward, requesting our County Council to take action in the matter, will appear in our 'Proceedings.'

The accompanying map of the Thames Basin (Plate IV) will show that our county is already unduly drawn upon by nearly half the water-supply for London being derived from the valley of the Lea.

In conclusion, I will just refer to two points connected with the future supply of water to London—the possible pollution of the Chalk, and the advisability of obtaining a supply of water from a distant source.

On the first point Mr. Baldwin Latham said, in 1884, that "he thought it was hardly advisable to go to any great expense in taking water from the Chalk, seeing that there was a danger of its being seriously contaminated . . .; if the level of the water under London were lowered to any great extent, it was quite possible to cause a flow back from the lower part of the river (the Thames) . . . and eventually the whole body of the Chalk water might become contaminated."* The more we prevent the pollution of our rivers, the more do we pollute the water which percolates into the Chalk, for the sewage we divert from our rivers we put upon the land, and although much of it is doubtless absorbed by vegetation and converted into the nutritious products of our sewage-farms, much must sink through the superficial soil into the Chalk, and this, as the plane of saturation is lowered, will increase in quantity. Cemeteries on the Chalk are doubtless very potent factors in this contamination; and cess-pools in it, as they must in time make artificial swallow-holes and cause a rapid dissolution of the chalk, will add their quota. These, certainly, are decreasing in number as systems of drainage are becoming more general; but, with an increasing population, the pollution caused by sewage-farms and cemeteries must increase to a greater extent than that due to cess-pools decreases. Percolation through compact chalk will undoubtedly render harmless the greater part of any organic matter water may contain, but water gets through our Upper Chalk with very varying degrees of freedom, sometimes so freely that there can be no possibility of any chemical reaction or mechanical filtration. And even when there is such filtration, the well-known case of the epidemic of typhoid fever at Lausen in Switzerland, in 1872, proves that it does not effectually prevent the passage of germs of disease. An outbreak of typhoid fever occurred in the Furlenthal valley and contaminated the Furlenbach stream, water from which percolated through limestone under the Stockhalder mountain and rose in a spring at Lausen, forming part of its water-supply. The epidemic at Lausen was confined to those who drank this water, and experiments were afterwards made which proved that the water really *percolated* through porous strata from the Furlenbach to the Lausen spring, not being wholly conveyed by channels in the limestone.†

* 'Water Supply and Distribution,' p. 36. (International Health Exhibition. Conferences.)

† See 'British Medical Journal,' 13th March, 1880; also Balfour Browne's 'Water Supply,' pp. 79–82.

But we can never even be certain of the absence of fissures or channels through which water may freely flow. In our sewage-farms and cemeteries the ground is so frequently disturbed that such fissures may not show on the surface as swallow-holes, as they would do in course of time on undisturbed ground. There is far less likelihood of contamination from these sources in our rivers than there is in the chalk, for water is usually, and may be nearly always, taken from rivers above such sources of pollution, while borings are most frequently made in thickly populated localities, and almost necessarily where the ground is low.

But our rivers cannot be further drawn upon, and it seems therefore that London must, sooner or later, follow the example of other and much less wealthy towns, by obtaining a supplementary supply from a distant source. Liverpool now obtains its water from the Vyrnwy, Manchester from Thirlemere, and Glasgow from Loch Katrine, while there is a project on foot for Birmingham to obtain a supply from Central Wales. If London delays, the most accessible sources of supply may be taken up by our Midland towns.

The most feasible scheme appears to me to be to obtain a supplementary supply from Bala Lake, or some other lake or lakes in North Wales; or from Central Wales or Dartmoor.

The rainfall, in England, decreases from the west to the east; even in our own county the difference is apparent, the Colne river-basin on the west having a greater rainfall than has the Lea river-basin on the east. In North Wales, in the vicinity of Bala Lake, the rainfall is twice as great as it is in the neighbourhood of London. We can rely there upon an average annual rainfall of at least 50 inches; allowing 20 inches for evaporation and absorption by vegetation, there will be 30 inches available. This is five times as much, for every square mile of surface, as we can count upon in the London basin, and there is a collecting area which would at least suffice to supply the requirements of the increasing population of London for domestic purposes for many centuries.

More than twenty-five years ago Professor Ansted thus referred to the project to convey water from Bala Lake:—"Where there is a natural lake of pure water sufficiently large and well supplied to ensure a permanent supply, no better source can exist. Thus it has been proposed to convey the water of Bala Lake, in North Wales, to supply London with water; and the idea, though it has not been carried out, was by no means so extravagant as might at first be supposed. The enormous cost of conveyance is, of course, a great barrier against the adoption of any such plan, but the possession of a vast natural reservoir, always full of the purest water, is no slight matter."* Against this proposal the objection has been raised that the substitution of a soft-water for a hard-water supply might lead to lead-poisoning. No instance of such poisoning with a soft-water supply is, I believe, known, but the possibility of it may be prevented in two ways: (1) by still deriving a portion of our supply from chalk wells or from our rivers, the water in

* 'Applications of Geology,' pp. 85, 86.

which, being almost entirely derived from the overflow of our chalk reservoir, is nearly as hard as that obtained direct from the chalk, and mixing the two waters, much the larger proportion being the soft water from a distance; (2) by the adoption, universally, of a constant supply, and the consequent removal of all lead cisterns. Existing lead pipes will be sufficiently well protected by their present coating of lime, but all new pipes should, where possible, be of iron. But in any case there should be a constant supply, which, by the necessity for the employment of better fittings, and by less waste in taps not being turned and left open when the water is turned off at the main, to run to waste when it is turned on again, has been found rather to tend to economy in water than to an increased consumption. Cisterns are the great source of danger, for however pure the water may be that is sent into them, after standing for a time it is almost certain to become contaminated.

The enormous cost of the construction of a conduit from North Wales to London would be nothing to the advantage of the acquisition of a practically unlimited supply of such pure water as our mountain-lakes afford, taking into consideration the great wealth of London, and in course of years the cost would probably be covered, or at least the interest on the outlay would be covered by the saving in soap, and by the water being used in manufacturing processes for which our present hard water is unsuitable. Since Glasgow has had a soft-water supply it is estimated that £36,000 a year has been saved in soap. At the same rate London would save from a quarter to half a million a year. The actual saving would probably be at least half a million sterling per annum, for the water London is supplied with is harder than that formerly supplied to Glasgow. It has been shown that for every 1000 gallons of water used daily for washing and other purposes for which soap is employed, a saving of £146 per annum in soap at 4*d.* per lb. would be effected by using lake water in place of water of 18 degrees of hardness.* Presuming that our five and a half millions of people each use with soap a gallon of water daily, the saving by substituting lake water for water of the average hardness of the present London supply (about 16 degrees, per 100,000), would be nearly three-quarters of a million per annum.

For such purposes as watering roads and flushing sewers an ample supply of water could still be obtained from the Thames. Although I do not think it feasible to introduce a dual supply into dwelling-houses, part for drinking and part for other purposes, I do not see why we should water our roads and flush our sewers with water of the purity required for drinking, if we can obtain for such purposes a less pure supply at less expense, such as Thames water unfiltered.

Such questions as these, however, are merely matters of detail, and I only allude to them to show that there is a way out of the present difficulty of supplying London with water, without increasing the serious injury that is now being done to our county.

* See Parry's 'Water: Its Composition, Collection, and Distribution,' p. 46.

Indeed we ought to contend for a reduction, and a very considerable one, in the quantity of water taken from great depths in the Chalk.

Should the drain upon our resources increase, we shall have fulfilled the predictions of Dr. John Evans already quoted: we shall have fertile and even irrigated meadows converted into arid wastes; watercress-beds, now of fabulous value, brought to the resemblance of newly-mended turnpike-roads; all existing wells, many of them already some hundreds of feet in depth, dried; and even the canals and navigable rivers rendered liable to sink and be lost in their beds. Should it, on the contrary, decrease, by the introduction of an outside supply, several of our now declining industries, such as watercress-growing, agriculture, and corn-grinding by water-power, would revive, and London, the largest and wealthiest city in the world, would no longer be in its present precarious condition, liable at any time to run short of water or to be decimated by an epidemic caused by its contamination, but would rival ancient Rome in the grandeur of its aqueducts and in the quantity and purity of the water supplied to its inhabitants.

XIX.

THE APPLICATION OF PHOTOGRAPHY TO METEOROLOGY.

By Arthur W. Clayden, M.A., F.G.S., F.C.S., F.R.Met.Soc.

Read at St. Albans, 23rd March, 1891.*

In treating of the relation between Photography and Meteorology I do not intend to discuss anything like the whole subject. It would be easy to say a great deal upon the advantages of studying meteorological science in the interests of photographic art. Much more again could be said of the invaluable assistance which has been given to meteorology by the photographic registration of the movements of meteorological instruments. But to neither of these sections of our subject do I purpose to allude. I wish to treat of the assistance which photography can give to meteorology in the future rather than of what it has done for it in the past.

No doubt it is generally known what is meant by a British Association Committee. One was appointed last year in order to take up the question of Meteorological Photography. Its Chairman is Mr. G. J. Symons, F.R.S., and its other members are Professor Meldola, F.R.S., your own President, and myself. Mr. Hopkinson may fairly be called the founder of this Committee, for he suggested its formation, having been impressed by the value of the work done by a similar body whose aim is geological,† and it is by his invitation that I find myself saddled with the duties of Secretary. I wish some one else could have been found to take up this work, for I am very conscious that I can only give to the undertaking a small part of the time which it fully deserves.

Our instructions are, in the first place, to collect photographs of meteorological phenomena. Such a collection would form an invaluable record of phenomena which are sometimes so transient that only a few persons may witness them, and often so rare that a long life of keen observation may be passed without seeing them. The collection would be deposited in some convenient centre where it would be accessible to all who might wish to consult it either for purposes of research, or with an object of secondary importance, namely, to obtain the means of teaching others.

Clearly such a collection cannot be made by the unaided efforts of the Committee, for its members cannot be everywhere; therefore they appeal to Photographic Societies, Field Clubs, and photographers generally, asking them for the help which is essential to success. The difficulty is to make it quite clear what sort of things are wanted. First and foremost stands the fact that although each photograph in itself would have some value, that value would be vastly increased if we knew something of the circumstances under which it was taken.

* The Introduction to a Lecture illustrated by photographs of meteorological phenomena shown by the oxy-hydrogen lantern.

† See 'Trans. Herts Nat. Hist. Soc.,' Vol. VI, p. 49.

Hence we have issued some simple instructions as a guide to any who may be willing to co-operate with us (see p. 167), and also some printed forms upon which certain facts relating to each photograph should be recorded.

Perhaps the most important objects to be photographed are clouds. There are probably few owners of a camera who have not tried to obtain pictures of these beautiful objects; but they are by no means easy to take. The blue light of the sky affects a sensitive plate almost as much as the white light from the cloud. The exposure must therefore be very accurately judged, or the result will be unsatisfactory. I have read minute directions for cloud-photography in which you are told to stop down your lens to a small aperture, and then give an exposure of one second or more. This will do well enough if the clouds are stationary or nearly so, but as a rule they are not only in rapid movement, but also undergoing changes of shape and size far greater than is commonly supposed. Hence exposure must generally be limited to a fraction of a second or the detail will be greatly marred.

The stop of the lens must not then be small, and exposure must be very accurately judged, or the image will be too faint. Heavy clouds of the type of shower-clouds are the easiest to take in full daylight, and any kind of cloud which stands out dark against a background of either an evening or early morning sky can be secured without difficulty. But the crux of cloud-photography is to get good pictures of thin white clouds, such as cirrus, in the full glow of sunlight. It can be done, no doubt, with sufficient practice, but most people would fare much as I used to do myself, securing one respectable negative in perhaps twenty attempts.

Hence various devices have been resorted to. Some persons have tried a slow plate; others have placed a sheet of glass, tinted pale yellow, in front of the lens. I am not able to speak of either of these methods from personal experience, but the Committee hopes to receive examples of the results of each process, so that an opinion may be formed of their respective merits.

There is, however, a third method by which I know it is quite easy to secure good results even with the thinnest kinds of clouds. This is by fixing a mirror of black glass in front of the lens so that the plane of glass makes an angle of about 33 degrees with the axis of the lens. The theory of the method is simple, and, as it has been explained by Dr. Riggenbach in the 'Quarterly Journal of the Royal Meteorological Society' for October, 1887, I need not do more than give a very brief statement. The blue light of the sky is partially in the condition known as polarised, and a mirror of black glass upon which those polarised rays fall at a certain angle cannot reflect them. The object of the mirror is to stop these rays. Meanwhile the light from the clouds is not polarised, and is therefore reflected. Theoretically the mirror should be of great value for a cloud at right angles to the sun, and of little use for others close to the sun or nearly opposite; but as a matter of fact it serves a purpose quite apart from any question of polarisation. It

diminishes the whole brilliancy of illumination so greatly that there is comparatively little difficulty in judging the exposure. Indeed some of my best pictures represent clouds in such a position that the mirror should theoretically have been all but useless. Before I had the mirror I used to get good negatives now and then, but most of my attempts (at cirrus clouds) were failures. Now, using the reflector, I seldom have a failure unless I have committed one of those errors common to all photographers, such as exposing one plate twice.

The lantern-slides which I show this evening will enable a judgment to be formed as to how this method works. They will also indicate better than any number of words the great desirability of taking a series of views of the same cloud, or a number of views of the same part of the sky, at stated intervals of time, so that the photographs may not only record cloud-forms, but also some of their changes and something of their motion. As to the merit of the method, it should be remembered that all the negatives I have taken were done under the great disadvantage of the murky atmosphere of a London suburb. Clear, then, as some of them are, it stands to reason that much better work should be possible in the pure air of a country district.

For meteorological photography to be thoroughly successful, its devotees have to do some things which are not usually supposed to be wise. In the first place the dark slides should be kept charged with plates. This is apt to result in dust-specks and other photographic flaws; but a picture with one or two technical defects is better than no picture at all, and clouds will not often wait while the apparatus is prepared. It must be ready for use. For a similar reason I always keep my cameras set up in correct focus for a distant object. It never pays to try and focus on a cloud. The margins of the objects are often so ill-defined that focussing is a very troublesome matter. Everything should be adjusted to suit some distant thing, such as a church, a house, or a tree. Again, to get clouds well into the field of view, the camera should be mounted in some way that will permit of free movement. A ball-and-socket joint under the tail-board would do, but for myself I prefer to have the camera to swing bodily between two uprights as a gun swings on its trunnions. This is a much more rigid mount than the ball-and-socket, and it can easily be rigged up by any one who can handle simple tools.

There is one defect in the mirror-method which I ought to mention. This is that the image is reversed as regards right and left, but if the prints from it are transparencies on glass, this is, of course, got over.

Clouds, then, are the phenomena to which we would invite special attention. But there are many other things which should be recorded. For instance, floods following an extraordinary rainfall or sudden thaw, frozen rivers, remarkable hailstones, snow-crystals, and anything unusual produced by weather-changes. Even somewhat persistent objects, such as the glaciers of the

Alps, might afford very useful information, for it would be highly interesting to see a series of views of the same ice-stream at different dates and in different seasons. Evidences of abnormally severe winters, such as the one from which we are just emerging, would also be of great value in the future.

Perhaps the most fascinating of all branches of photography is taking pictures of lightning. Some years ago the Royal Meteorological Society took up this work, and it now possesses a fine series of lightning photographs, copies from some of which I am enabled by the courtesy of the Society to show upon the screen.

Many of the results recorded by these photographs coincided exactly with anticipation from the analogy between a lightning-flash and an electric spark. Others, however, were entirely unexpected, the strangest being the occurrence of some flashes which show dark in the print. For some time the explanation of this was unknown. Most people believed it to be due to some form of photographic reversal similar to that which causes the image of any very bright object to print black. However, the flashes did not seem brilliant enough to act in such a way, so the point was a puzzle until I had the good fortune to light upon the proof that the darkness was due to reversal. I found that the latent image of a lightning-flash or electric spark which would develop normally may be reversed by exposing the plate before development to some diffused light. The glare from another flash or spark reflected from a white background such as a cloud can effect this reversal, but it seems essential that the diffused light should be subsequent of the impression of the latent image. My experiments have been fully confirmed by Mr. Shelford Bidwell, F.R.S., so that I have no misgivings about it. Nevertheless we should like to get two photographs of the same flash, one showing it bright and the other dark.

Another strange thing was that many lightning-flashes seemed to be broad ribbons of light or a volley of parallel flashes following each other through a complicated series of twists and turns. What were these? Mr. W. Marriott and Mr. Ranyard found that all, or at least most of them, had been taken in a camera held in the hand. No doubt those who took them relied upon the statements in all books on electricity as to the extremely short duration of a flash. I never had any doubt upon this point myself until I saw the photographs. Then came a photograph taken by Dr. Hoffert. He deliberately swayed his camera from side to side, and the resulting picture showed a series of flashes following one another along the same or a precisely similar path, while something kept shining all the time and produced broad streaks across the negative.

Lightning is, then, certainly not always the single instantaneous flash it has been supposed to be. It often consists of a volley of sparks, and it is about those volley flashes that we want more knowledge.

Nothing is easier than to photograph lightning provided a

thunderstorm occurs at night. Fix the camera by an open window (for Mr. Whipple, of Kew Observatory, has shown that the glass might give a double image), turn it in the direction in which flashes seem frequent, take off the cap, and wait until a flash has crossed the field of view, and then change the plate. Those who have two cameras might do useful work by keeping one in motion while the other was fixed, in the hope of getting another photograph like Dr. Hoffert's, with its fellow taken in the fixed camera.

In lightning-photography I believe there is a wide field for research, but what I have said as to the necessity of recording the conditions under which cloud-photographs are taken applies even more strongly to lightning. The remarks on focus also apply, for it is practically impossible to focus on the flashes themselves.

In all photographs it is desirable if possible to include a part of something fixed, such as the top of a flag-pole, a chimney, or a church spire. Such an object gives a point of reference which is especially useful when cloud-changes are represented. But besides this, something should be introduced whenever possible to serve as a rough scale. Photographs of snow-drifts and the like may be rendered absolutely useless by the absence of any such scale. Again, other subjects, such as hoar-frost, and damage by lightning, should not only be photographed so as to give a general view, but the details should be brought out in other pictures so as to show as far as possible all that can be seen.

I cannot help feeling that I have given only a scanty outline of our aim and desires. Nevertheless I do hope that some members of the Hertfordshire Natural History Society may be induced to co-operate with us. We do not in the least degree wish to turn any one aside from the pleasant search after all that is beautiful or strange or rare, but only to point out new objects full of beauty and of great interest, and to ask for copies of photographs of them.*

I shall always be most willing to give any explanation or other assistance in my power to all who are ready to co-operate in the advancement of meteorological science by means of photography.

The instructions of the Committee are appended.

* Prints, which may be mounted or unmounted, should be sent to me at Warleigh, Tulse Hill Park, London, S.W.

APPENDIX.

Instructions of the British Association Committee on Meteorological Photography.

Photographs are desired of clouds, lightning, hoar-frost, remarkable hailstones, snow-wreaths, avalanches, glaciers, storm-waves, waterspouts, tornadoes, dust-whirls, halos, parhelia, or of any other meteorological phenomena or their consequences.

General Instructions.

1. As soon as possible after exposing a plate, number it and fill in the details relative to it on one of the forms supplied. The more completely these are filled in the more valuable will the photograph be.
2. The size of the plate is immaterial provided that the focus is sharp. Use a magnifier when focussing, and for objects like clouds focus upon a distant tree or building.
3. Use a lens which does not distort the image.
4. Do not touch up either negative or print.
5. When photographing any object which is moving or changing, a series of views taken at short intervals, so as to show the progress of the phenomenon, will be of especial value.
6. Whenever possible, a figure or other object of known dimensions should be introduced, in order to serve as an approximate scale.

Cloud Photography.

For heavy clouds no special apparatus is required, but exposure must be shorter than for ordinary landscape work. For very thin clouds exposure must be extremely short and development very cautious. Fair results may then be occasionally obtained without special means.

In order to obtain better and more certain results three methods have been adopted:—

(*a*) Using a slow plate and rapid lens, with short exposure.

(*b*) Using an ordinary plate and lens, but with a sheet of pale yellow glass in front of the lens.

(*c*) Using an ordinary plate and lens, but placing a plane mirror of black glass in front of the lens so that its surface makes an angle of about 33 degrees with the axis of the lens. The image reflected in the mirror is fairly easy to photograph.

The Committee hopes to receive examples of each of these processes, as well as examples and descriptions of any other special devices which may be adopted by observers.

Lightning Photography.

When a thunderstorm occurs at night it is very easy to photograph the flashes of lightning.

Fix the camera rigidly (do not hold it in the hand) and expose it to a part of the sky where flashes are frequent.

As soon as one flash has crossed the field of view change the plate.

Whenever possible, count the number of seconds between seeing the flash and hearing the beginning of the thunder. Note this time on the print or form.

If you have two cameras some useful results may be attained by using one as described above and holding the other in the hand, pointing in about the same direction, but kept in constant oscillation. It is hoped that two photographs of the *same flash* may be thus secured.

Another desirable experiment is to fix both cameras in the same direction, change the plates in one after each flash, but leave the plate exposed in the second until six or eight flashes have crossed the field of view.

If the camera is placed in a window this must be open, as the interposition of a window pane may give rise to multiple images.

Be particularly careful to note the exact time and direction of each flash photographed.

A rapid lens, with a stop $\frac{f}{8}$ or thereabouts, should be used for lightning.

XX.

METEOROLOGICAL OBSERVATIONS TAKEN AT THE GRANGE, ST. ALBANS, DURING THE YEAR 1890.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc., President.

Read at Watford, 16th March, 1891.

Longitude of Station, 0° 20′ 7″ W.; Latitude, 51° 45′ 9″ N. Cistern of barometer 388 feet, ground-level at thermometer-screen 380 feet, and at rain-gauge 379 feet, above Ordnance Datum. Thermometers 4 feet, and top of rain-gauge 1 foot above the ground. Observations taken at 9 a.m.

The accompanying tables (pp. 170, 171) give the monthly means, etc., of the daily observations in 1890, and the following is the usual summary for the seasons.

Means for the Seasons from Dec. 1889 to Nov. 1890.

Seasons, 1889–90.	Pressure.	Temperature.		Tension of Vapour.	Humidity.	Rainfall.		Cloud, 0–10.
		Mean.	Daily Range.			Total.	Days.	
	ins.	°	°	in.	%	ins.		
Winter	30·125	38·0	10·9	·204	91	5·11	50	6·6
Spring	29·856	47·0	16·0	·264	80	5·35	45	7·2
Summer.....	29·942	58·5	15·8	·284	79	8·91	56	6·8
Autumn.....	30·058	50·1	15·6	·317	87	4·62	42	6·7

In the next table the chief results, monthly and annual, are compared with the means for ten years at Watford.

Difference in 1890 from Means of 1877–86 at Watford.

Months.	Pressure.	Temperature.		Tension of Vapour.	Humidity.	Rainfall.		Cloud, 0–10.
		Mean.	Daily Range.			Total.	Days.	
	in.	°	°	in.	%	ins.		
January.....	—·089	+4·6	+2·0	+·035	=	+0·35	+ 5	—1·1
February	+·273	—3·3	—0·1	—·032	=	—1·80	— 8	—1·2
March	—·118	+1·3	+0·2	+·027	+ 2	+1·01	+ 4	+0·8
April	—·030	+1·0	+0·1	—·012	+ 2	—1·05	+ 1	+1·5
May	—·101	+1·5	+0·3	+·032	+ 5	—1·06	— 2	=
June	+·035	—0·9	1·9	—·001	+ 5	—0·10	+ 4	+0·9
July	—·037	—2·2	—2·1	—·019	+ 5	+1·64	+ 4	+0·9
August	—·024	—2·1	—0·3	—·020	+ 4	—0·64	+ 5	—0·2
September	+·203	+2·7	+1·9	+·045	+ 1	—2·02	— 6	+1·1
October	+·191	+0·7	+2·7	=	+ 1	—1·61	— 4	—0·2
November	—·032	+0·3	+0·3	—·003	— 1	—0·44	+ 4	—0·1
December	+·101	—8·6	1·3	—·065	— 3	—1·97	— 3	+0·3
Year	+·031	—0·4	—0·1	—·001	+ 2	—7·69	+ 4	+0·2

Results of Meteorological Observations taken at The Grange, St. Albans, in 1890.

Months.	Pressure of the Atmosphere.	Temperature of the Air.										Humidity of the Air		
		9 a.m.	Means of		Mean.	Mean Daily Range.	Absolute Min. and Max.				Absolute Range.	Dryness.	Tension of Vapour.	Relative Humidity.
			Min.	Max.			Min.	Date.	Max.	Date.				
	ins.	°	°	°	°	°	°		°		°	°	in.	%
January	29·940	40·8	35·7	47·1	41·2	11·4	20·0	2nd	56·4	7th	34·6	2·8	·229	90
February	30·231	35·2	32·0	42·2	36·5	10·2	25·8	28th	48·4	1st	22·6	2·9	·183	89
March	29·858	42·1	35·1	50·1	42·4	15·0	15·8	4th	66·5	29th	40·7	4·2	·237	85
April	29·846	44·9	37·0	53·5	45·1	16·5	30·1	5th	63·6	30th	33·8	6·7	·231	78
May	29·864	54·1	44·1	62·5	53·6	18·4	33·5	4th	75·7	24th	42·2	7·1	·323	77
June	30·004	57·1	49·7	65·9	57·6	16·2	37·0	1st	75·5	25th	38·5	6·9	·366	78
July	29·915	58·8	51·5	66·6	59·0	15·1	44·1	12th	73·7	16th	29·6	6·8	·388	78
August	29·907	58·6	51·1	67·1	58·9	16·0	40·1	31st	78·1	5th	38·0	5·9	·399	81
September	30·174	59·3	49·9	68·1	59·1	18·2	38·0	1st	75·9	10th	37·9	4·8	·425	84
October	30·119	48·1	41·3	57·5	49·0	16·2	25·9	28th	68·7	14th	42·8	3·6	·295	88
November	29·880	41·7	36·4	48·7	42·3	12·3	18·8	29th	55·0	14th	36·2	4·4	·231	88
December	30·067	28·0	24·7	33·5	28·7	8·8	12·7	23rd	41·9	4th	29·2	3·8	·134	87
Year	29·984	47·4	40·7	55·2	47·8	14·5	12·7	Dec.	78·1	Aug.	65·4	4·8	·287	84

RESULTS OF METEOROLOGICAL OBSERVATIONS TAKEN AT THE GRANGE, ST. ALBANS, IN 1890—*(continued)*.

MONTHS.	RAINFALL.					CLOUD.			WIND.										
	Total Fall.	Max. fall in 24 hours.		No. of days of		Mean Amount, 0–10.	No. of days of		Mean Force, 0–12.	Number of days of									
	Ins.	Ins.	Date.	Rain or Snow.	Snow only.		Clear Sky.	Over-cast.		N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
January	2·94	·29	26th	22	0	6·5	6	14	2·1	2	0	1	1	6	12	5	3	1
February	·79	·40	14th	9	3	6·4	6	10	1·9	5	9	6	2	1	1	1	2	1
March	2·67	·72	19th	16	5	7·1	4	17	2·3	1	5	0	1	4	11	7	3	0
April	1·33	·28	15th	16	0	8·0	2	14	1·7	6	8	2	3	1	3	3	3	1
May	1·35	·41	9th	13	0	6·4	5	10	1·7	0	8	8	3	2	3	4	2	1
June	2·76	·98	4th	18	0	7·2	0	11	1·8	3	2	1	4	1	10	5	2	2
July	4·17	2·00	17th	19	0	7·4	1	12	2·0	2	2	1	0	2	8	8	7	1
August	1·98	·43	19th	19	0	6·7	3	10	2·1	4	2	2	2	1	7	9	4	0
September	·59	·19	21st	7	0	7·5	4	12	1·9	1	1	2	3	5	7	4	2	5
October	1·45	·50	7th	13	1	6·3	9	12	2·2	2	1	0	1	1	9	8	7	2
November	2·58	·61	6th	22	4	6·4	5	14	1·9	3	2	0	2	2	7	7	3	4
December	·66	·20	18th	14	12	7·6	7	20	1·5	2	7	9	3	2	0	1	1	6
Year	23·27	2·00	July	188	25	7·0	52	156	1·9	31	47	32	25	28	78	62	38	24

The mean temperature of the year was rather low; the mean daily range was about the average. There were no high maxima, the extreme being 78°·1 in August, but in December the low minimum of 12°·7 was reached. The temperature was exceedingly variable, January being very mild, February very cold, the spring warm, summer cold, autumn warm, and December excessively cold, its mean temperature being 12°·5 lower than that of January, which is usually the colder month. The actual minimum in December, though low, is not exceptionally so, the cold being characterised by its persistence rather than by its severity.* The mean temperature from 26th November to 20th January, a period of eight weeks, was 29°·3, or 2°·7 below freezing point, and during this long period the minimum sank below this point every night but three (5th and 6th Dec. 1890, and 14th Jan. 1891). The mean pressure of the atmosphere was a little above the average of the ten years 1877–86 at Watford. The lowest pressure recorded at 9 a.m. was 28·712 ins. on 23rd January, and the highest was 30·717 ins. on 23rd February, giving a range of 2·005 ins. The rainfall was considerably below the average. July was very wet, 4·17 ins. of rain falling; Feb., Sept., and Dec., were very dry, having an aggregate rainfall of only 2·04 ins. The air was rather humid and the sky rather cloudy.

In the winter of 1889–90 (Dec. to Feb.) the mean pressure of the atmosphere was rather high, the mean temperature was about the average, and the rainfall was very small. In the spring (March to May) mean pressure was rather low, mean temperature rather high, and rainfall small. In the summer (June to Aug.) mean pressure was about the average, mean temperature very low, and rainfall heavy, with many wet days. In the autumn (Sept. to Nov.) mean pressure was rather high, mean temperature high, and rainfall very small. In each season the relative humidity was great, and while the sky was comparatively clear in the winter, it was unusually cloudy in the spring. The deviations from the means of our period are as follows:—

Difference in 1888–89 from Means of 1877–86 at Watford.

Seasons, 1889–90.	Pressure.	Temperature.		Tension of Vapour.	Humidity.	Rainfall.		Cloud, 0–10.
		Mean.	Daily Range.			Total.	Days.	
	in.	°	°	in.	%	ins.		
Winter	+·141	+0·1	+0·9	+·001	+ 2	−2·70	− 1	−0·9
Spring	−·083	+0·5	−0·4	+·016	+ 3	−1·10	+ 3	+0·8
Summer.....	−·009	−1·7	−1·4	−·010	+ 4	+0·90	+13	+0·2
Autumn.....	+·121	+1·2	+1·7	+·014	+ 3	−4·07	− 6	+0·2

* In an account of "The Great Frost of 1890–1891," in 'Quart. Journ. R. Met. Soc.,' vol. xvii, p. 93, Mr. Charles Harding says that "so far as the southern portion of England is concerned, there does not seem during the last [*i.e.* present] century to have been any such prolonged period of frost as that of 1890–91."

Notes on the Months.

January.—Very warm, rather bright, with an atmosphere of average humidity and rather low pressure, and a rather heavy rainfall on a large number of days. Rain fell every day for the last eleven days, the average per day being 0·13 in.: no snow fell. The temperature was exceedingly variable. Coldest day 2nd, mean 27°·6; warmest days 6th, mean 49°·3, and 7th, mean 49°·4. Min. below 32° on 6 days, below 22° on 1 day (2nd); max. above 42° on 26 days, above 52° on 4 (6th, 7th, 9th, and 25th).

February.—Very cold, rather bright, with an atmosphere of average humidity and very high pressure, and a very small rainfall on a small number of days. On 14th and 15th there was a storm, with rain, then snow, and then rain again, the amount (as rain) for the two days being 0·70 in., leaving only 1·07 in. for the rest of the month. The mean temperature of the first two days was 44°·9, being 7°·8 above that of the month. Coldest day 28th, mean 30°·6; warmest day 1st, mean 46°·5. Min. below 32° on 15 days; max. above 42° on 15. Several days were foggy.

March.—Rather warm, and cloudy, with a rather humid atmosphere of low pressure, and a rather heavy rainfall on a considerable number of days Rain fell every day from 18th to 25th, the average per day being 0·23 in. A little snow fell on several days. The mean temperature of the first four days was 27°·3, being 15·3 below that of the month. Coldest day 3rd, mean 25°·4; warmest day 29th, mean 53°·5. Min. below 32° on 7 days, below 22° on 3 (2nd, 3rd, and 4th); max. above 52° on 14 days, above 62° on 3 (28th, 29th, and 30th).

April.—Rather cold, very cloudy, with a humid atmosphere of low pressure, and a small rainfall on a considerable number of days. The days on which rain fell were 6th to 9th, 14th to 18th, and 21st to 27th, there being thus three wet and four dry periods. Coldest day 12th, mean 39°·5; warmest day 30th, mean 53°·2. Min. below 42° on 27 days (every day but 7th, 15th, and 16th), below 32° on 6; max. above 52° on 18, above 62° on 1 day (30th).

May.—Rather warm, of average cloudiness, with a humid atmosphere of low pressure, and a small rainfall on a rather small number of days. The days on which rain fell were 4th to 11th, 16th to 19th, and 29th, there being thus (if the 20th to 31st with only one wet day be considered a dry period) two wet and three dry periods. Coldest day 31st, mean 46°·6; warmest day 25th, mean 63°·7. Min. below 42° on 9 days; max. above 62° on 14, above 72° on 2 (24th and 25th).

June.—Rather cold and cloudy, with a humid atmosphere of rather high pressure, and an average rainfall on a considerable number of days. More than one-third of the rain in the month fell on the 4th, and more than half on the 4th and 30th together. Coldest day 1st, mean 50°·5; warmest day 24th, mean 63°·6. Min. below 52° on 24 days, below 42 on 2 (1st and 8th); max. above 62° on 24, above 72° on 4 (16th, 17th, 24th, and 25th).

July.—Cold and cloudy; with a humid atmosphere of rather low pressure, and a very heavy rainfall on a large number of days. The excess in the rainfall is more than covered by the heavy fall of 2 inches on the 17th, the heaviest in the year. Rain fell every day for the first twelve days. Coldest day 5th, mean 52°·4; warmest day 22nd, mean 63°·9. Min. below 52° on 17 days; max. above 62° on 26 days, above 72° on 2 (16th and 23rd).

August.—Rather cold and bright, with a humid atmosphere of rather low pressure, and a rather small rainfall, but on a large number of days. Coldest day 30th, mean 51°·6; warmest day 1st, mean 66°·5. Min. below 52° on 12 days (every day from 24th to 31st), below 42° on 2 (30th and 31st); max. above 62° on 26 days, above 72° on 4 (1st, 4th, 5th, and 6th).

September.—Rather warm and cloudy, with a rather humid atmosphere of high pressure, and an exceedingly small rainfall on a very small number of days, the only days on which rain fell being the 17th to 23rd, with an average of 0·074 in. per day. Coldest day 1st, mean 52°·8; warmest day 5th, mean 64°·6. Min. below 52° on 20 days, below 42° on 1 day (1st); max. above 62° every day but one (29th), above 72° on 5 days.

October.—Rather warm, of average cloudiness and humidity, with an atmosphere of high pressure, and with a very small rainfall. Snow first fell on 26th. Coldest day 28th, mean 35°·0; warmest day 1st, mean 58°·6. Min. below 42° on 16 days, below 32° on 3 (27th, 28th, and 29th); max. above 62° on 10.

November.—Of average temperature, cloudiness, and humidity, with an atmosphere of rather low pressure, and a rather heavy rainfall on a considerable number of days. Coldest day 28th, mean 23°·5; warmest day 20th, mean 52°·5. Min. below 42° on 22 days, below 32° on 8, below 22° on 2 (28th and 29th); max. above 52° on 13 days (below 32° on 28th).

December.—Excessively cold, rather cloudy, with a dry atmosphere of rather high pressure, and a very small rainfall, all the amount gauged except 0·06 in. on 3rd and 4th together, being due to snow, which fell on a good many days, but in very small quantities. Coldest day 22nd, mean 19°·9; warmest day 4th, mean 38°·4. Min. below 42° every day, below 32° every day but 4 (3rd to 6th), on two of which it was exactly 32°, below 22° on 10; max. above 32° on 21 days, never rising to 42°. The temperature at 9 a.m. was above 32° only on the first seven days in the month.

XXI.

THE PERCOLATION OF RAIN THROUGH COMPARATIVELY LIGHT AND THROUGH COMPARATIVELY HEAVY SOIL.

By Edward Mawley, F.R.Met.Soc., F.R.H.S.

Read at Watford, 13th April, 1891.

Before considering the observations themselves it may not be out of place if I preface this modest enquiry with a brief history and description of the percolation-gauges with which they were made.

About ten years ago, when residing at Croydon, I was desirous of testing for horticultural purposes the effect of mulching upon the moisture and temperature of the ground. I consulted my friend Mr. Baldwin Latham, M.Inst.C.E., also a resident in Croydon, and well known as a leading authority on all matters relating to underground-water, and he advised me to employ for this purpose percolation-gauges similar to those he had then in use in his own garden. Acting upon Mr. Latham's suggestion I had made two open slate cisterns, each three feet square and three feet deep. These were sunk into the ground to within a few inches of their upper edges, and in the centre of the bottom of each cistern was inserted a pipe which led into a small covered chamber at the side. Over the bottoms of these cisterns I placed a layer of pebbles, and over these some gravel, the two layers taken together being three inches deep. The cisterns were then filled up with ordinary garden soil to the depth of thirty inches, or to within three inches of the top of them. The stones and gravel were introduced beneath the soil with a view to equalise the drainage over the whole area of each of these percolation-gauges, for such they had now become. In the chamber at the side under the ends of the conducting-pipes were placed cans capable of holding several gallons of water apiece, to receive the drainage from the gauges. In the centre of each gauge was inserted one of Symons' earth-thermometers, with its bulb at the depth of one foot below the surface of the soil.

I was so much pleased with the working of these gauges that when I removed to Berkhamsted, about six years ago, I brought them with me and had them sunk side by side in my present garden in a line with my rain-gauges and other meteorological instruments. The mulching experiments having been completed, I thought that it would be interesting to employ them here as permanent percolation-gauges. One of the gauges was accordingly filled with some of the lightest soil, and the other with some of the heaviest soil obtainable in the neighbourhood. In all other respects, however, the arrangements are precisely the same as those I have described as having been used for the experiments at Croydon. The light soil is composed chiefly of disintegrated clay, vegetable earth, and numerous flints; while the heavy soil is mostly a stiff yellow clay with an equally liberal addition of flints. Both are natural soils and were placed in the gauges as nearly as

practicable in the same order they occupied in the spots from which they had been dug. In order to prevent cracks forming in dry weather, the surface of the soil in each gauge is hoed regularly once a week to the depth of about an inch. This also serves to keep down weeds.

Although the gauges were filled during the autumn of 1885, nearly 2½ years were allowed to elapse before any regular measurements were made, as it was considered advisable to allow the soils sufficient time to settle down and become fairly consolidated. Of course in such confined spaces there is little hope of their ever becoming anything like as firm as in their natural state.

From Table I it will be seen that the total rainfall for the whole period over which these observations extend (April, 1888, to March, 1891) was 73½ inches. Of this amount 47 inches, or about 63·9 per cent., passed through the 2½ feet of comparatively heavy soil, and 43½ inches, or 59·2 per cent., through the same depth of lighter soil; so that the drainage through the more retentive soil exceeded that through the lighter soil by altogether 3½ inches, or 7½ per cent. It therefore follows that the evaporation from the surface of the heavy soil must have fallen short of that from the surface of the light soil by precisely the same amount, viz. 3½ inches.

We come next to Table II, which gives the rainfall, percolation, and evaporation for the summer halves of three drainage years. It may be here explained that what is termed a "drainage year" begins with October and ends with the following September, and that the summer half of it commences with April and ends with September. Taking the totals for these three summers it will be found that the heavy-soil drainage amounted to 45 per cent. of the rainfall, whereas that through the light soil was only 36·9 per cent., or 8·1 per cent. less. It will also be noticed that the total evaporation from the light soil exceeded the drainage through it by about 10 inches, whereas from the heavier soil it was only 4 inches in excess of the drainage.

In Table III will be found similar data for the winter halves of three drainage years beginning in each case with October and ending with the following March. This is the period when there is least evaporation, and therefore when the drainage is at its maximum. Indeed, it might almost be said that our underground water-supply would never be replenished at all were it not for these winter rains; for in Nature it is seldom that the rain which falls during the rest of the year has any chance of finding its way permanently into the ground. The difference between the quantities passing through the two soils during this period, owing to the small amounts evaporated from their surfaces, will be seen to have been but slight. In fact the drainage through the heavier soil was 85·4 per cent., and that through the lighter soil 84·6 per cent. of the aggregate rainfall, or a difference in favour of the heavier soil of barely 1 per cent. The differences between the quantities evaporated consequently also come out small.

TABLE I.—*The amounts of Rainfall, Drainage, and Evaporation for three Years* (*April*, 1888–*March*, 1891).

Years.	Rainfall.	Drainage.			Evaporation.		
		Heavy soil.	Light soil.	Heavy + or — light soil.	Heavy soil.	Light soil.	Heavy + or — light soil.
1888-89	26·779	17·350	16·841	+0·509	9·429	9·938	−0·509
1889–90	26·787	18·777	17·035	+1·742	8·010	9·752	−1·742
1890–91	20·010	10·851	9·592	+1·259	9·159	10·418	−1·259
Sums	73·576	46·978	43·468	+3·510	26·598	30·108	−3·510
Mean monthly	2·044	1·305	1·207	+0·098	0·739	0·836	−0·098

TABLE II.—*The amounts of Rainfall, Drainage, and Evaporation for three Summers* (1888–90).

Year.	Rainfall.	Drainage.			Evaporation.		
		Heavy soil.	Light soil.	Heavy + or — light soil.	Heavy soil.	Light soil.	Heavy + or — light soil.
1888	13·095	5·484	4·996	+0·488	7·611	8·099	−0·488
1889	14·620	7·836	6·177	+1·659	6·784	8·443	−1·659
1890	11·646	4·418	3·341	+1·077	7·228	8·305	−1·077
Sums	39·361	17·738	14·514	+3·224	21·623	24·847	−3·224
Means	13·120	5·913	4·838	+1·075	7·208	8·282	−1·075

TABLE III.—*The amounts of Rainfall, Drainage, and Evaporation for three Winters* (1888–89—1890–91).

Year.	Rainfall.	Drainage.			Evaporation.		
		Heavy soil.	Light soil.	Heavy + or — light soil.	Heavy soil.	Light soil.	Heavy + or — light soil.
1888–89	13·684	11·866	11·845	+0·021	1·818	1·839	−0·021
1889–90	12·167	10·941	10·858	+0·083	1·226	1·309	−0·083
1890–91	8·364	6·433	6·251	+0·182	1·931	2·113	−0·182
Sums	34·215	29·240	28·954	+0·286	4·975	5·261	−0·286
Means	11·405	9·747	9·651	+0·096	1·658	1·754	−0·096

On examining the daily records I find that on twenty-two occasions during the three years the drainage ceased altogether through the two soils. On nine of these the drainage stopped on the same day in both gauges; on four that from the light-soil gauge stopped first; and on the remaining nine occasions it was that from the heavy-soil gauge which first came to a standstill. There are a good many instances when the drainage re-commenced on the same day from both gauges, and there are several instances when the drainage came first through the heavier soil, but none in which that from the light-soil gauge took the lead.

The mean difference in the temperature of the two soils at one foot deep at 9 a.m., during the whole period of three years, is very slight, the heavy soil proving the colder by less than the tenth of a degree. On rare occasions the light-soil temperature exceeded that of the heavier soil by from half a degree to a whole degree, but by never more than this. During settled weather the differences in the readings of the two thermometers are very trifling, but sudden changes of temperature are almost invariably more quickly indicated by the one in the lighter than by that in the heavier soil.

From the foregoing results the following conclusions may, I think, be fairly drawn:—

1. Taking the whole year, there is greater evaporation from the surface of a comparatively light soil than from soil of a more retentive nature; and consequently less rain passes through it than through the same thickness of heavier soil.

2. The differences between the two soils as regards drainage and evaporation are considerably greater during the summer than during the winter half of a drainage-year.

3. During dry weather the heavier soil invariably retains more moisture than the lighter one.

4. The lighter soil is slightly warmer, but less equable in temperature than the heavier soil.

Had the difference between the two soils been greater, the contrast in the results would necessarily have been much more striking; moreover the number of flints in both soils no doubt tends to increase and at the same time to equalise the drainage from the two gauges, the heavier soil being so much more dependent on these stones for the ready passage of water through it than is the lighter soil. It should be clearly understood that the surface of the soil in each gauge is frequently hoed and thus kept free from vegetation.

XXII.

REPORT ON THE RAINFALL IN HERTFORDSHIRE IN 1890.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc., President.

Read at Watford, 13th April, 1891.

There are several alterations in the staff of our observers of the rainfall in 1890, but the number of stations in our principal table remains the same as in the previous year. The return for Nash Mills being incomplete, owing to the gauge having been burst by the frost in November, that of the same observers for Apsley Mills, within a very short distance, is substituted for it; the falls of snow in March and December at Gorhambury not having been measured or estimated and added to the rainfall, the return for that station is omitted; and the observer at Bushey Heath has not sent in his return, reporting that his record is imperfect On the other hand, a new station has been started on Berkhamsted Common by Mr. W. Bonner Hopkins, at Fairhill; and Messrs. Paul & Son have communicated their return for the Old Nurseries, Cheshunt.

These alterations reduce the number of returns for the river-district of the Ver from four to three, and for that of the Lower Colne from three to two; and increase the number for the district of the Bulbourne from two to three, and for that of the Lower Lea from four to five. There are still five districts without observers: the Upper Ivel in the north, the Chess in the south-west, the Brent and the Upper Colne (*i.e.* the Colne above its junction with the Ver) in the south, and the Stort in the east. The only desideratum mentioned in the report for 1888 which has since been supplied is a second observer in the district of the Beane.

Of the 30 stations from the returns for which the main portion of the present report is drawn up, I have the daily rainfall at 23, the same number as before. The records of the 8-inch and the $\frac{1}{1000}$-acre gauge at Rothamsted are given in a supplementary table, as also are those for Nash Mills and Gorhambury, the probable fall at Nash Mills in November being computed, and additions for snow being made to the record for Gorhambury. A return for Hitchin, giving the daily rainfall, has been received from Mr. Francis Ransom; but, as his gauge has been moved during the year from Fairfield to Bedford Road, the record is given in the supplementary table. The new station will probably appear in the principal table in the report for 1891.

The total number of stations for which returns have been received is therefore 33, and of gauges 35; and the number of daily records received is 24.

Particulars of the 30 rainfall stations from the returns for which the mean rainfall, etc., for the county is deduced, and the monthly and total rainfall and number of days on which at least 0·01 inch of rain fell at these stations, are given in Tables I and II, pp. 180, 181. The supplementary table (Table III, p. 182) gives the annual rainfall recorded by the five other gauges mentioned above.

Table I.—Hertfordshire Rainfall Stations.

River District.			Station.	Observer.	Latitude.	Longitude.	Diameter of Gauge.	Height of Gauge above Ground.	Height of Gauge above Sea-level.
					° ′ ″	° ′ ″	ins.	ft. ins.	ft.*
Ouse	Cam	Rhee	Royston	Hale Wortham	52 2 34 N	0 1 8 W	8	0 6	269
	Ivel	Hiz	Hitchin—The Firs	William Lucas	51 57 0 N	0 16 20 W	5	2 1	238
			„ High Down	Joseph Pollard	51 57 40 N	0 20 0 W	5	1 1	422
	Thame	Up. Thame	Tring Vicarage	Rev. W. Quennell	51 47 33 N	0 39 25 W	5	1 0	442
			Cowroast	Hubert Thomas, C.E.	51 47 0 N	0 36 30 W	10	4 2	345
		Bulbourne	Berkhamsted—Rosebank	Edward Mawley	51 45 40 N	0 33 30 W	8	1 0	401
			„ Fairhill	W. Bonner Hopkins	51 46 0 N	0 32 50 W	5	1 0	550
		Gade	Great Gaddesden Vicarage	Rev. W. T. Drake	51 47 20 N	0 30 30 W	8	1 0	427
	Colne		H. Hempsted—Apsley Mills	J. Dickinson & Co.	51 44 15 N	0 27 30 W	24	0 9	260
		Ver	Kensworth—The Grove	Miss S. Grace Jones	51 51 30 N	0 30 0 W	5	1 0	630
			Harpenden—Rothamsted	Lawes and Gilbert	51 48 10 N	0 21 30 W	5	0 9	420
			St. Albans—The Grange	John Hopkinson	51 45 9 N	0 20 6 W	5	1 0	380
		Lo. Colne	Watford—Oaklands	Edward Harrison	51 40 5 N	0 24 20 W	5	5 6	273
			Rickmansworth—Moor Park	Rt. Hon. Lord Ebury	51 37 30 N	0 26 20 W	5	2 0	340
Thames		Mimram	Welwyn Rectory	Rev. Canon Wingfield	51 49 50 N	0 12 30 W	5	0 4	228
			Datchworth Rectory	Rev. J. Wardale	52 2 0 N	0 10 0 W	5	1 0	386
		Beane	Stevenage—Weston Manor	Marlborough R. Pryor	51 57 20 N	0 9 30 W	5	0 9	500 ?
			Bennington Lodge	Rev. J. D. Parker, LL.D.	51 53 45 N	0 5 20 W	5	1 0	408
		Rib	Therfield Rectory	Rev. J. G. Hale	52 1 0 N	0 3 0 W	5	4 3	500
			Throcking Rectory	Rev. C. W. Harvey	51 57 5 N	0 3 0 W	5	1 0	484
		Ash	Much Hadham	T. Woodham Mott	51 51 24 N	0 4 38 E	5	1 0	222
	Lea		Hatfield—Brocket Hall	J. Landon	51 48 0 N	0 14 0 W	8	1 0	250 ?
		Upper Lea	Hertford—Bayfordbury	W. Clinton Baker	51 46 30 N	0 5 30 W	8	1 2	250
			Ware—Red House	Joseph Francis, C.E.	51 46 0 N	0 6 0 W	12	3 0	114
			„ Fanhams Hall	Miss Joyce Croft	51 49 30 N	0 1 30 W	8	1 0	253
			Broxbourne—Stafford House	G. J. Newbery	51 44 30 N	0 1 0 W	5	1 0	118
		Lower Lea	Cheshunt—Old Nurseries	Paul and Son	51 42 0 N	0 3 0 W	5	1 0	92
			„ College	Rev. Dr. Reynolds	51 42 5 N	0 2 50 W	5	1 0	94
			New Barnet—Gas Works	T. H. Martin, C.E.	51 39 5 N	0 10 15 W	8	0 9	212
			Southgate—The Lawns	George A. Church	51 37 40 N	0 8 0 W	5	0 6	240

* For explanation of these symbols see p. 84.

Table II.—Rainfall in Hertfordshire in 1890.

Stations.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Days.
*Royston	1·80	·80	2·38	·63	1·84	1·84	3·83	1·42	·17	1·67	1·75	·55	18·68	146
Hitchin—The Firs	2·29	·73	2·52	·62	1·92	1·93	4·11	2·03	·26	1·57	1·89	·67	20·54	171
* ,, High Down	2·21	·54	2·20	·74	1·90	1·87	4·09	2·08	·39	1·52	1·89	·80	20·23	170
*Tring Vicarage	3·20	·83	2·53	1·36	1·49	2·22	4·64	3·34	·53	1·66	2·54	·70	25·04	182
*Cowroast	3·12	·81	2·78	1·32	1·35	2·49	3·89	2·57	·63	1·66	2·37	·77	23·76	143
*Berkhamsted—Rosebank	2·58	·80	2·60	1·27	1·34	2·49	3·67	2·20	·68	1·49	2·51	·65	22·28	179
* ,, Fairhill	2·93	·65	2·67	1·19	1·34	2·32	3·59	2·30	·70	1·52	2·50	·74	22·45	184
*Great Gaddesden Vicarage	2·78	·65	2·19	1·18	1·45	2·34	3·94	2·46	·67	1·60	2·43	·53	22·22	174
H. Hempsted—Apsley Mills	1·60	·73	2·45	1·57	1·35	2·38	3·62	2·15	·83	1·40	2·43	·09	20·60	150
*Kensworth—The Grove	2·26	·66	2·92	1·16	1·57	2·24	3·93	4·03	·61	1·87	2·02	·89	24·16	157
*Harpenden—Rothamsted	2·94	·75	2·75	1·22	1·34	2·36	4·49	2·42	1·11	1·48	2·64	·42	23·92	169
*St. Albans—The Grange	2·94	·79	2·67	1·35	1·35	2·76	4·17	1·98	·59	1·45	2·58	·66	23·29	188
*Watford—Oaklands	3·19	·80	2·52	1·88	[1·33]	2·92	4·42	2·36	·83	1·46	2·36	·13	[24·20]	[176]
*Rickmansworth—Moor Park	3·70	·84	2·48	1·49	1·31	3·19	6·77	2·32	·82	1·52	2·84	·40	27·68	185
*Welwyn Rectory	2·51	·76	2·81	·89	1·69	2·18	5·09	1·83	·55	1·20	3·07	·54	23·12	155
*Datchworth Rectory	2·19	·70	2·27	·98	1·50	2·16	4·01	2·42	·56	1·44	2·39	·45	21·07	159
Stevenage—Weston Manor	2·25	·74	2·28	·37	·86	2·79	5·11	2·03	·38	·73	1·14	·44	19·12	127
*Bennington Lodge	2·51	·73	2·87	1·19	1·68	2·80	4·47	2·64	·54	1·76	2·75	·45	24·39	188
*Therfield Rectory	2·11	·74	2·31	·67	1·95	2·47	5·42	1·75	·33	1·96	2·29	·85	22·85	168
*Throcking Rectory	2·17	·72	2·31	·54	1·68	2·13	3·88	1·87	·59	1·81	2·43	·60	20·73	171
*Much Hadham	2·17	·93	2·60	1·11	1·66	2·45	4·11	2·46	·33	2·07	2·63	·55	23·07	166
Hatfield—Brocket Hall	2·49	·79	2·42	·98	1·45	2·12	4·75	2·21	·52	1·48	2·79	·71	22·71	138
Hertford—Bayfordbury	2·38	·80	2·11	·87	1·50	2·04	3·49	1·92	·59	1·38	2·41	·55	20·04	176
*Ware—Red House	2·10	·73	2·40	·75	1·38	2·49	3·54	1·84	·40	1·31	2·48	·39	19·81	152
* ,, Fanhams Hall	2·15	·78	2·31	1·01	1·69	2·32	4·21	2·20	·34	1·49	1·65	·47	20·62	171
*Broxbourne	2·44	·93	1·60	·94	1·52	2·37	4·47	2·63	·62	1·45	2·49	·40	21·86	192
*Cheshunt—Old Nurseries	2·29	·87	2·22	1·07	1·51	2·62	4·15	2·76	·83	1·35	2·54	·51	22·72	144
,, College	2·37	·82	2·35	1·00	1·65	2·24	4·61	2·73	·99	1·46	2·26	·60	23·08	127
*New Barnet—Gas Works	2·51	·98	2·09	1·48	1·24	2·24	4·98	3·11	·72	1·19	2·40	·45	23·39	129
Southgate—The Lawns	2·40	1·06	2·41	1·83	1·50	3·40	4·34	2·49	·56	1·33	2·07	·68	24·07	188
Mean for the County	2·49	·78	2·43	1·09	1·51	2·41	4·32	2·35	·59	1·51	2·35	·56	22·39	164

* Daily fall received from the observers at these stations.

TABLE III.—SUPPLEMENTARY TO TABLES I AND II.

DISTRICT.	STATION.	OBSERVER.	GAUGE.	RAINFALL.	DAYS.
			ins.	ins.	
Hiz	Hitchin	F. Ransom	5	21·89	197
Gade	Nash Mills	J. Dickinson & Co.	12	21·94	151
Ver	Rothamsted	Lawes & Gilbert	8	23·54	166
	,,	,,	72×87	24·78	177
	Gorhambury	Earl of Verulam	6 sqr.	21·21	

The mean rainfall in the county in the year 1890 was 22·39 inches. This is 4·35 ins. below the mean for the 10 years 1880–90, and 4·04 ins. below that for the half-century 1840–89 uncorrected for disparity of distribution of the gauges prior to the last decade. For the last nine years each third year has been a dry one, the mean rainfall in Hertfordshire during this period having been as follows: *—

1882 ..... 30·57	1885 ..... 29·00	1888 ..... 26·09
1883 ..... 26·95	1886 ..... 27·50	1889 ..... 27·50
1884 ..... 20·63	1887 ..... 19·73	1890 ..... 22·39
Mean ..... 26·05	Mean ..... 25·41	Mean ..... 25·33

On the 17th of July there was a very heavy fall of rain over the whole county. Though not so heavy at most stations as the fall of the 12th of July, 1889, it was more general than that, everywhere exceeding an inch; and while that was lightest in the south-west, this was heaviest there, the fall at Moor Park, Rickmansworth, 4·19 ins., being unprecedented in the annals of Hertfordshire. It is the heaviest fall recorded in England on this day, but a gauge at Hillingdon, near Uxbridge, holding 4 inches, overflowed, and there are several records of between 3 and 4 inches. There can be no doubt as to its correctness. In a letter which appeared in the 'Times' of 26th July, Mr. G. J. Symons, F.R.S., says: "I have had returns from that station for some years, and had every reason to believe them to be correct, but in order to place the record beyond suspicion I went to Moor Park, tested the gauge, cross-examined one of the gardeners who saw the measurement made, and examined the paths and flower-beds in the garden, the result being that I have not the shadow of a doubt as to the accuracy of the record—a fall in twelve hours of about twice the average for the whole month."

Distribution of Rainfall throughout the Year.—Of the total rainfall 17 % fell during the winter months (Jan., Feb., and Dec.), 23 % during the spring (March to May), 40 % during the summer (June to Aug.), and 20 % during the autumn (Sept. to Nov.). The fall during each quarter and each season, and the deviation from the mean for the half-century, 1840–89, was as follows:—

* Here and elsewhere the values are expressed in inches.

	Fall.	Diff.		Fall.	Diff.
1st quarter.....	5·70	+0·07	Winter	3·83	—2·17
2nd ,, ...	5·01	—1·00	Spring	5·03	—0·49
3rd ,, ...	7·26	—0·05	Summer	9·08	+2·10
4th ,, ...	4·42	—3·06	Autumn	4·45	—3·48

February, September, and December were very dry; July was the only very wet month. The difference in each month from the mean for the half-century was:—

Jan.	+0·18	April.....	—0·69	July	+1·82	Oct.	—1·43
Feb.	—0·93	May	—0·62	Aug.....	—0·03	Nov.	—0·21
Mar.	+0·82	June.....	+0·31	Sept.....	—1·84	Dec.	—1·42

Thus the fall up to the end of July was more than an inch above the mean, but for the last five months in the year nearly five inches below the mean, an average defect of an inch per month.

The absolute minimum fall in any one day in each month, and the station recording it, was:

Jan. 26—Moor Park	0·48	July 17—Moor Park	4·19
Feb. 15—Cheshunt College	0·72	Aug. 19—Kensworth.....	1·20
Mar. 19—Welwyn	1·05	Sept. 23—Rothamsted	0·61
April 15—Southgate	0·43	Oct. 7—Throcking	0·64
May 10—Royston	0·60	Nov. 6—Moor Park.....	0·82
June 4—St. Albans	0·98	Dec. 18—Cheshunt College.....	0·34

The wettest day in each month at the 30 stations was:

January 24th at 1 station, 25th at 1, 26th at 3, 27th at 24, 26th and 27th equal at 1.

February 14th at 21, 15th at 9.

March 19th at 29, 24th at 1.

April 15th at 20, 21st at 1, 25th at 3, 26th at 5, 15th and 26th equal at 1.

May 9th at 25, 10th at 4, 15th at 1.

June 4th at 1, 10th at 3, 12th at 8, 30th at 17, 10th and 30th equal at 1.

July 17th at all stations.

August 10th at 12, 11th at 4, 19th at 13, 28th at 1.

September 17th at 6, 19th at 3, 21st at 11, 23rd at 8, 17th and 23rd equal at 1, 17th and 25th equal at 1.

October 7th at all stations.

November 4th at 5, 6th at 22, 23rd at 3.

December 4th at 2, 18th at 21, 19th at 5, 27th at 1, 18th and 19th equal at 1.

The day in each month on which a heavy fall of rain was most general over the county was therefore:

Jan. 27th.	April 15th.	July 17th.	Oct. 7th.
Feb. 14th.	May 9th.	Aug. 19th.	Nov. 6th.
Mar. 19th.	June 30th.	Sept. 21st.	Dec. 18th.

The number of wet days in the year (average of the 30 gauges) was 164, being 4 below the mean of the 20 years 1870–89. Of the total number there were 35 (or 21 %) in the winter months, 41 (or 25 %) in the spring, 52 (or 32 %) in the summer, and 36 (or 22 %) in the autumn.

The number of wet days in each month, and the deviation from the mean of the previous 20 years, was as follows:

Jan.	20 +5	April	14 +1	July	18 +4	Oct.	11 —4
Feb.	7 —7	May	12 —1	Aug.	17 +4	Nov.	19 +3
Mar.	15 +2	June	17 +4	Sept.	6 —7	Dec.	8 —8

Distribution of Rainfall throughout the County.—The mean rainfall in the catchment-basin of the Ouse was 19·82 ins., and in that of the Thames 22·68 ins. The following table (Table IV) gives the mean fall for each month and for the year in each of the five river-districts represented, and in the county for comparison, and also the difference in the year from the mean of the previous ten years.

Table IV.—Rainfall in the River-Districts.

Months.	Cam.	Ivel.	Thame.	Colne.	Lea.	County.
	ins.	ins.	ins.	ins.	ins.	ins.
January	1·80	2·25	3·20	2·80	2·32	2·49
February	·80	·64	·83	·75	·82	·78
March	2·38	2·36	2·53	2·60	2·33	2·43
April	·63	·68	1·36	1·36	·98	1·09
May	1·84	1·91	1·49	1·37	1·53	1·51
June	1·84	1·90	2·22	2·55	2·43	2·41
July	3·83	4·10	4·64	4·25	4·41	4·32
August	1·42	2·05	3·34	2·48	2·31	2·35
September	·17	·33	·53	·75	·55	·59
October	1·67	1·54	1·66	1·55	1·46	1·51
November	1·75	1·89	2·54	2·47	2·36	2·35
December	·55	·74	·70	·53	·54	·56
Year	18·68	20·39	25·04	23·46	22·04	22·39
Diff. from 1880–89	−4·82	−4·88		−5·91	−4·25	−4·35

The mean fall in each of the minor river-basins, or sub-districts, was as follows :—

Cam	Rhee	18·68
Ivel	Hiz	20·39
Thame	Upper Thame	25·04
Colne	Bulborne	22·83
	Gade	21·41
	Ver	23·79
	Lower Colne	25·94
Lea	Mimram	22·10
	Beane	21·75
	Rib	21·79
	Ash	23·07
	Upper Lea	21·59
	Lower Lea	23·02

The total yearly fall ranged from 18·68 ins. at Royston to 27·68 ins. at Moor Park, Rickmansworth, and the total monthly fall, from 0·09 in. at Apsley Mills, Hemel Hempstead, in December, to 6·77 ins. at Moor Park, in July. The greatest fall in any one day was 4·19 ins. at Moor Park on the 17th of July.

Distribution of Rainfall in each Month.—The nomenclature used in the following account of the chief falls of rain is the same as in previous reports, falls of at least ½ inch being styled *considerable*, ¾ inch *very considerable*, 1 inch *great*, 1¼ inch *very great*, 1½ inch *heavy*, 1¾ inch *very heavy*, and of 2 inches and upwards *excessive*. This analysis only applies to the 24 stations from which I have returns of the daily rainfall, except when the fall, being at least half an inch, was the maximum in the month.

JANUARY.—Rather wet, but on no day was there a *considerable* fall of rain at any station. There were only two or three days together without rain except at a very few stations, and at most stations rain fell every day for the last 11 days. No snow is recorded to have fallen.

FEBRUARY.—Very dry: at most stations there were two or three periods of about a week without rain. On 14th the fall was *considerable* at four stations, and on 15th at one. A little snow fell in the middle and near the end of the month.

MARCH.—Rather wet, but with several intervals of a few days without rain. On 19th the fall was *great* at Welwyn (1·05 in.), *very considerable* at sixteen stations, and *considerable* at seven. This was chiefly due to snow, small amounts of which also fell during the first few days, and a little on the 20th, the last fall of the winter.

APRIL.—Rather dry, with no *considerable* fall of rain on any day. Periods with rain for several days in succession alternated with similar periods without rain; thus at six stations there were three such wet periods and four dry ones, of nearly equal length.

MAY.—Rather dry, and very similar in character to April as to periods of rainfall. On 9th the fall was *considerable* at ten stations, and on 10th at three. Scarcely any rain fell after 19th, the average for the last 12 days being only 0·106 in., or at the rate of 0·009 in. per day, being about one-seventh the mean daily fall for the year.

JUNE.—Rather wet; with very few days in succession without rain. On 4th the fall was *very considerable* at one station; on 10th *considerable* at one; on 12th *very considerable* at one and *considerable* at five; on 13th *considerable* at one, and on 20th at one; and on 30th *very considerable* at two and *considerable* at six.

JULY.—Excessively wet, as in the preceding year, and as then the excess was entirely due to a fall caused by a thunderstorm about the middle of the month, the rain in each case falling in two successive days, and being much the heaviest in the first of the two. On 4th the fall was *very considerable* at two stations and *considerable* at six. On 17th, the day of the thunderstorm, the fall was (at least) *great* at *all* stations. For this day I give all the records I have obtained, *i.e.* including a few at stations for which I have not received returns of the rainfall during the year. The fall was *excessive* at Moor Park (4·19 ins.), Welwyn Rectory (2·70 ins.), Danesbury, Welwyn (2·64 ins.), Brocket Hall (2·55 ins.), Rothamsted (5 inch gauge 2·52 ins., 8 inch gauge 2·50 ins.), Therfield (2·48 ins.), Haileybury, Hertford (2·48 ins.), Bushey Heath (2·15 ins.), New Barnet (2·10 ins.), Gorhambury, St. Albans (2·08 ins. + ?, gauge overflowed), Bancroft, Hitchin (2·02 ins.), High Down, Hitchin (2·00 ins.), and The Grange, St. Albans (2·00 ins.); *very heavy* at Royston (1·99 in.), Datchworth (1·91 in.), The Firs, Hitchin (1·88 in.), The Maples, Hitchin (1·87), Watford House (1·83 in.), Southgate (1·82 in.), Oaklands, Watford (1·81 in.), and Weston Manor, Stevenage (1·75 in.); *heavy* at Great Gaddesden

(1·73 in.), Rose Bank, Berkhamsted (1·71 in.), Elstree (1·66 in.), Bennington (1·66 in.), Fanhams Hall, Ware (1·65 in.), Cheshunt Nurseries (1·62 in.), Cheshunt College (1·55 in.), Tring (1·54 in.), and Fairhill, Berkhamsted (1·51 in.); *very great* at Apsley Mills, Hemel Hempstead (1·47 in.), Kytes, Watford (1·46 in.), Hyde Hall, Buntingford (1·40 in.), Kensworth (1·27 in.), and Cowroast (1·25 in.); and *great* at Throcking (1·24 in.), Bayfordbury, Hertford (1·22 in.), Much Hadham (1·21 in.), and Red House, Ware (1·12 in.). On 18th the fall was *great* at Therfield (1·08 in.) and Bennington (1·02 in.), *very considerable* at eight stations, and *considerable* at ten.

August.—Rainfall about the average, the heaviest falls being during the first half of the month, and on the 19th, but the longest continuous period of rain being after that date. On 10th the fall was *very considerable* at one station and *considerable* at four; on 11th *great* at New Barnet (1·02 in.) and *considerable* at three stations; on 19th *great* at Kensworth (1·20 in.) and *considerable* at five stations; and on 24th *considerable* at one station.

September.—Very dry. At five stations no rain fell from 29th August to 16th September inclusive, a period of 19 days, and the average at all stations during this period was only 0·028 in., or at the rate of about 0·002 in. per day, being less than one-thirtieth the mean daily fall for the year. There was no rain at ten stations for the first sixteen days, and none at fourteen for the 14 days 3rd to 16th. On 23rd the fall was *considerable* at two stations.

October.—Rainfall about half the average. Scarcely any rain fell up to 7th, and after that for another 6 days, but it was more frequent during the latter part of the month. The only *considerable* fall was on 7th, at nine stations. There was a little snow on 26th, the first fall of the winter.

November.—Rainfall a little below the average, and distributed pretty equally over the month. On 4th the fall was *considerable* at two stations; on 5th at one; and on 6th it was *very considerable* at one station and *considerable* at sixteen. A little snow fell during the last few days.

December.—Very dry, with no *considerable* fall of rain or snow on any day. Owing to the persistent frost and the practice of some observers not to melt and measure small quantities of snow in their gauges, but to let them accumulate until a heavy fall or a thaw comes, the number of days of rain or snow recorded is less than it should have been. No fall was recorded at Cowroast from 5th to 30th inclusive, nor at Oaklands, Watford, from 9th to 31st; at most stations there was no fall from 5th to 13th; and at several the period without any was prolonged to beyond this date, in some cases to 18th. Nearly all the small amount gauged during the month was due to snow.

XXIII.

CLIMATOLOGICAL OBSERVATIONS TAKEN IN HERTFORDSHIRE IN 1890.

By John Hopkinson, F.L.S., F.G.S., F.R.Met.Soc., President.

Read at Watford, 13th April, 1890.

Observations were continued during the year 1890 at the five stations for which the reports for the three previous years were drawn up, and therefore I have only to give similar tables to those in my previous reports, and to make a few brief remarks on the general result.

The mean temperature of Hertfordshire in 1890, deduced from observations at these five stations, was 0°·6 above that of the three previous years, and 0°·9 below the mean of 1882–86. The mean daily range was 0°·8 more than in 1887–89, and 0°·2 less than in 1882–86. The extreme range was about the same as in 1887, and much greater than in 1888 and 1889, this being due to low minima in December. The relative humidity, amount of cloud, and rainfall, were rather less than in the three previous years; and while the rainfall was considerably less than in 1882–86, the number of rainy days was rather greater than in those years. While thus having about an average temperature and a small rainfall, the year 1890 had a very wet summer and a very cold December.

The observations are made at 9 a.m. at all the stations, maximum temperature and rainfall being entered to the previous day.

ROYSTON.

(London Road.)

Latitude: 52° 2′ 34″ N. Longitude: 0° 1′ 8″ W. Altitude: 301 feet.

Observer: *Hale Wortham, F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	41·6	36·4	46·8	10·4	23·1	53·8	90	6·9	1·80	18
Feb.	37·1	31·6	42·7	11·1	23·0	51·0	89	6·8	·80	9
March	43·1	34·3	51·8	17·5	15·3	62·8	85	6·5	2·38	12
April	45·5	36·1	54·9	18·8	26·2	64·7	82	5·3	·63	13
May	55·3	44·0	66·6	22·6	35·2	77·0	77	5·0	1·84	12
June	59·9	50·0	69·8	19·8	37·9	78·9	79	7·3	1·84	13
July	59·1	51·1	67·1	16·0	41·0	78·9	77	6·8	3·83	13
August	60·2	50·3	70·0	19·7	38·3	83·7	80	6·0	1·42	15
Sept.	60·3	50·4	70·3	19·9	38·2	76·0	77	4·5	·17	4
Oct.	50·1	42·3	58·0	15·7	31·8	68·1	80	5·1	1·67	14
Nov.	42·8	36·6	48·9	12·3	15·2	59·0	91	7·3	1·75	17
Dec.	28·5	24·1	32·9	8·8	4·3	42·3	88	8·1	·55	11
Year	48·6	40·6	56·6	16·0	4·3	83·7	83	6·3	18·68	151

BERKHAMSTED.

(Rose Bank.)

Latitude: 51° 45′ 40″ N. Longitude: 0° 33′ 30″ W. Altitude: 400 feet.

Observer: *Edward Mawley, F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	41·9	36·6	47·2	10·6	17·6	54·6	89	7·3	2·58	22
Feb.	37·1	31·7	42·4	10·7	25·6	49·5	91	7·4	·80	7
March	42·2	35·0	49·4	14·4	13·8	62·7	86	7·3	2·60	16
April	44·8	36·6	53·1	16·5	26·7	63·0	76	7·5	1·27	14
May	52·4	42·0	62·7	20·7	35·7	76·3	68	6·5	1·33	12
June	57·2	48·4	66·0	17·6	33·6	74·6	75	7·6	2·49	17
July	58·5	50·4	66·7	16·3	41·4	75·0	78	8·3	3·67	20
August	58·3	49·9	66·7	16·8	36·9	77·9	80	7·1	2·21	18
Sept.	58·5	48·5	68·4	19·9	35·6	75·0	84	5·9	·68	8
Oct.	48·9	40·5	57·4	16·9	24·3	68·7	87	6·0	1·49	14
Nov.	41·9	35·4	48·3	12·9	20·0	56·4	91	7·3	2·51	20
Dec.	28·4	24·2	32·6	8·4	11·1	42·3	93	9·4	·65	11
Year	47·5	39 9	55·1	15·2	11·1	77·9	83	7·3	22·28	179

ST. ALBANS.

(The Grange.)

Latitude: 51° 45′ 9″ N. Longitude: 0° 20′ 7″ W. Altitude: 380 feet.

Observer: *John Hopkinson, F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	41·4	35·7	47·1	11·4	20·0	56·4	90	6·5	2·94	22
Feb.	37·1	32·0	42·2	10·2	25·8	48·4	89	6·4	·79	9
March	42·6	35·1	50·1	15·0	15·8	66·5	85	7·1	2·67	16
April	45·2	37·0	53·5	16·5	30·0	63·6	78	8·0	1·33	16
May	53·3	44·1	62·5	18·4	33·5	75·7	77	6·4	1·35	13
June	57·8	49·7	65·9	16·2	37·0	75·5	78	7·2	2·76	18
July	59·0	51·5	66·6	15·1	44·1	73·7	78	7·4	4·17	19
August	59·1	51·0	67·1	16·0	44·0	78·1	81	6·7	1·98	19
Sept.	59·0	49·9	68·1	18·2	38·0	75·9	84	7·5	·59	7
Oct.	49·4	41·3	57·5	16·2	25·9	68·7	88	6·3	1·45	13
Nov.	42·5	36·4	48·7	12·3	18·8	55·0	88	6·4	2·58	22
Dec.	29·1	24·7	33·5	8·8	12·7	41·9	87	7·6	·66	14
Year	48·0	40·7	55·2	14·5	12·7	78·1	84	7·0	23·27	188

BENNINGTON.

(Bennington Lodge.)

Latitude: 51° 53′ 45″ N. Longitude: 0° 5′ 20″ W. Altitude: 407 feet.

Observer: *Rev. J. D. Parker, LL.D., F.R.Met.Soc.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	41·8	36·6	47·0	10·4	22·6	53·9	90	7·1	2·51	25
Feb.	37·0	31·8	42·2	10·4	25·2	49·3	88	6·8	·73	8
March	42·1	35·3	48·9	13·6	17·2	62·0	86	7·4	2·87	15
April	44·8	36·7	52·8	16·1	29·0	62·1	75	7·4	1·19	15
May	52·9	43·0	62·8	19·8	36·3	74·5	68	6·6	1·68	13
June	57·3	48·5	66·2	17·7	37·1	75·2	74	7·6	2·80	17
July	58·9	50·7	67·0	16·3	42·2	74·8	75	8·1	4·47	20
August	58·7	50·0	67·4	17·4	39·0	78·8	77	7·3	2·64	20
Sept.	59·2	49·9	68·5	18·6	39·1	76·1	79	5·6	·54	9
Oct.	49·0	40·8	57·3	16·5	26·7	68·7	80	5·5	1·76	15
Nov.	42·2	36·4	48·0	11·6	17·2	58·2	88	7·5	2·75	21
Dec.	28·7	24·4	32·9	8·5	14·4	41·7	89	8·4	·45	10
Year	47·7	40·3	55·1	14·8	14·4	78·8	81	7·1	24·39	188

NEW BARNET.

(Gas Works.)

Latitude: 51° 39′ 5″ N. Longitude: 0° 10′ 15″ W. Altitude: 212 feet.

Observer: *T. H. Martin, C.E.*

Months	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	41·5	35·4	47·7	12·3	15·0	59·8	88	6·5	2·51	17
Feb.	36·8	29·6	43·9	14·3	21·5	50·0	91	6·1	·98	6
March	41·8	32·1	51·5	19·4	9·0	66·5	93	6·7	2·09	15
April	44·9	34·9	54·9	20·0	23·6	63·6	80	5·9	1·48	12
May	52·5	40·7	64·6	24·3	31·0	75·0	79	6·2	1·24	11
June	58·3	47·9	68·6	20·7	35·5	77·2	84	7·0	2·24	17
July	59·8	50·3	69·4	19·1	37·0	77·5	78	7·5	4·98	15
August	59·1	48·8	69·4	20·6	33·1	80·5	78	6·0	3·12	13
Sept.	58·3	45·9	70·6	24·7	31·0	82·0	82	5·0	·72	5
Oct.	48·5	38·5	58·5	20·0	16·0	69·0	87	4·7	1·19	10
Nov.	42·4	35·6	49·2	13·6	16·0	57·5	88	6·8	2·40	17
Dec.	29·2	23·4	35·0	11·6	8·0	45·2	87	8·3	·45	5
Year	47·7	38·5	56·9	18·4	8·0	82·0	85	6·5	23·40	143

HERTFORDSHIRE.

Means of Climatological Observations (with extremes of temperature) in 1890, at Royston, Berkhamsted, St. Albans, Bennington, and New Barnet.

Months	Temperature of the Air						Humidity	Cloud, 1–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Jan.	41·6	36·1	47·1	11·0	15·0	59·8	89	6·9	2·47	21
Feb.	37·0	31·3	42·7	11·4	21·5	51·0	90	6·7	·82	8
March	42·4	34·1	50·4	16·0	9·0	66·5	87	7·0	2·52	15
April	45·0	36·2	53·8	17·6	23·6	64·7	78	6·8	1·18	14
May	53·3	42·7	63·9	21·2	31·0	77·0	74	6·1	1·49	12
June	58·1	48·9	67·3	18·4	33·6	78·9	78	7·3	2·43	16
July	59·1	50·8	67·4	16·6	37·0	78·9	77	7·5	4·22	17
August	59·1	50·0	68·1	18·1	33·1	83·7	79	6·5	2·27	17
Sept.	59·1	48·9	69·2	20·3	31·0	82·0	81	5·7	·54	7
Oct.	49·2	40·7	57·7	17·0	16·0	69·0	84	5·5	1·51	13
Nov.	42·8	36·1	48·6	12·5	15·2	59·0	89	7·1	2·40	20
Dec.	28·8	24·2	33·4	9·2	4·3	45·2	89	8·4	·55	10
Year	47·9	40·0	55·8	15·8	4·3	83·7	83	6·8	22·40	170

Results of Climatological Observations, 1887–89.

Stations.	Temperature of the Air						Humidity	Cloud, 0–10	Rain	
	Means				Extremes				Am'nt	Days
	Mean	Min.	Max.	Range	Min.	Max.				
	°	°	°	°	°	°	%		ins.	
Royston	48·0	40·2	55·7	15·5	12·0	89·4	85	6·5	21·29	158
Berkhamsted	46·9	39·6	54·2	14·6	11·2	85·0	83	7·3	24·74	180
St. Albans	47·3	40·4	54·2	13·8	13·7	86·0	83	7·0	25·86	181
Bennington	46·9	40·1	53·7	13·6	15·1	85·1	83	7·7	24·00	194
New Barnet	47·2	38·4	55·9	17·4	8·0	88·5	84	6·3	22·61	144
County	47·3	39·8	54·8	15·0	8·0	89·4	84	7·0	23·70	171

XXIV.

REPORT ON DISEASES OF PLANTS IN HERTFORDSHIRE IN 1890.

By A. T. Brett, M.D.

Read at Watford, 13th April, 1891.

When, last April, I invited our Society to study the injuries to and diseases of plants, I thought I might be poaching on the domains of our recorder of injurious insects; but, although many diseases are caused by insects, others are caused by fungi, and it is to such that I wish particularly to direct attention.

Two diseases due to fungi were very prevalent in Hertfordshire and elsewhere last year. I allude to the disease called "club" in cabbage and "aubury" or "finger-and-toe" in turnips, and to the potato disease. The former is caused by the slime-fungus, *Plasmodiophora brassicæ*, and the latter by the fungus known as *Peronospora infestans*.

A farmer near Watford had a large field of turnips nearly destroyed by the slime-fungus. I took some specimens to Miss E. A. Ormerod, and she informed me that gas-lime was a sovereign remedy for this disease. When residing at Isleworth she cured "club" in the cabbage roots in her garden by its application, the roots having previously looked like tuberculated maces. The knowledge of the great utility of gas-lime had spread to such an extent that while it could be had for the carting when she went to Isleworth in 1874, when she removed to St. Albans, in 1888, it was charged 7*s.* the cart-load, and she thought it would be a real boon to farmers generally to know how useful gas-lime is, and precisely how it acts.

The potato disease appears to be disseminated in great measure by carelessness and want of knowledge of the necessity of killing the spores of the fungus which causes it. On these points Mr. J. W. Odell, of Stanmore, who has devoted considerable attention to the subject, says: "Gardeners and farmers are heavily handicapped in their attempts to keep the disease under by the thoughtless practice of those people who take no steps to kill the spores. I have seen this season, on cottagers' gardens, the haulms and diseased tubers lying about, in this state, tainting the whole neighbourhood with the conidia, the slightest puff of wind being sufficient to send off the germs in all directions. This is, in my opinion, a criminal practice, and should be stopped by the law. Another practice is to give pigs the tubers when they are in an advanced stage of disease, the spores being by this means distributed throughout the manure-heap ready to be again committed to the garden for further development. It cannot be too strongly urged upon potato growers that it is madness on their part to allow either tops or tubers to remain undestroyed. They should either be burned or buried in quick-lime, the former method being the best. Land upon which diseased potatoes have been grown should be subjected to a good dressing of hot lime, and then thrown up rough

so as to allow the frost to penetrate as far as possible. Much is being done,—by selecting seed (potatoes) capable of resisting disease, and by growing more earlier-ripening varieties,—to keep the disease within bounds, but whatever is done is being as effectually undone by the practices that I have referred to. What is wanted is more knowledge on the part of cottagers and others who grow potatoes, for when they know more of the nature and life-history of the potato fungus, I feel sure that they will take every precaution against its dissemination." Mr. Odell also informs me that "M. Prillieux in France, and Mr. C. M. Weed at the Ohio Experimental Station, U.S.A., have found Bordeaux mixture to be highly fatal to the potato fungus. It is applied," he says, "with a syringe and sprayed over the foliage, and is usually made of 6 parts of sulphate of copper and 6 parts of quick-lime to 100 parts of water. M. Prillieux has recently informed Dr. Plowright that a 3 per cent. solution is better than a 6 per cent."

The hollyhock disease was very prevalent in my garden last year. I sent specimens of the diseased leaves to Mr. E. M. Chater, and he informed me that he found the growth on the under side of the leaves to be clusters of the spores of a species of *Puccinia*, and that he had observed a similar fungus on the leaves of the common mallow (*Malva silvestris*). It appears that the disease first attacks the mallow, the fungus being bred upon its leaves, and the spores thence sent abroad to prey upon the leaves of the hollyhock.

The only other diseased condition of plants which has been brought under my notice is that of fasciation. In a letter dated the 5th of July, Mr. J. W. Odell says: "I send you a plant of *Campanula media* (Canterbury bell) showing a strongly-affected condition of fasciation. You will notice that there is a suppression of the floral envelopes which in many flowers are represented by mere rudiments in a contorted state. The reproductive organs are in some flowers absent, in others the stigmas show a tendency to revert to a foliar type. Other plants from the same batch of seeds show signs of fasciation, inherited no doubt from the parent plants, but, in the case of the plant sent, developed to an abnormal condition by liberal feeding."

I should be glad to receive notes on this subject from members of the Hertfordshire Natural History Society, the West Herts Agricultural Society, the St. Albans Farmers' Club, or from any farmer or gardener. Information as to remedies which have proved successful would be especially welcome.

XXV.

MISCELLANEOUS NOTES AND OBSERVATIONS.

Meteorology.

Read at St. Albans, 22nd December, 1890.

*A Meteorite observed in Switzerland.**—The following note may be regarded as bearing some relation to the inquiry made in 1887 into the phenomena noticed in Hertfordshire and the neighbouring counties on the 20th of November in that year.†

On the 20th of June, 1890, I was walking along a mountain-road in the Vaudois Alps, at an elevation of 3445 feet above the level of the sea, when I saw fall perpendicularly at some distance from me, an object which was only visible by the well-defined streak of white light to which its passage through the air gave rise. This was at approximately ten minutes past five (Bern time) in the afternoon. The sun was shining brightly behind me, and I was looking towards the E., across a valley, at a mountain (the Grand Muveran), which presented to me, at a distance of about four miles, a wall of reddish-grey rock, rising at the summit of the mountain to an elevation of 10,040 feet above sea-level. It was precisely between the point at which I stood, a mile or so to the S.W. of the village of Gryon, and this wall of rock, that the streak of light was seen. I heard no noise of any kind. Upon a line of four miles in length, crossing rough and wooded ground, it seemed useless to search for any solid fragment which may have reached the earth, and, in fact, no search has been made. The Swiss newspapers‡ record two other observations on the same day and at the same time, which, without doubt, are referable to the same meteorite. They were (1) near Bern, at a distance of 50 miles to the N.N.E. from Gryon, and (2) near Geneva, at 43 miles due W. Between these two points is a distance of about 80 miles. The notices in the newspapers are very short. Near Bern the observers were four members of the Federal Assembly, and the bolide is said to have fallen at a few hundred yards in front of them, leaving a bluish-white streak, recalling exactly the electric light. A similar streak was noticed near Geneva, but a bolide does not appear to have fallen in that neighbourhood, as it is spoken of as "approaching the horizon." No sound is mentioned in connection with these observations. In this case, therefore, the two approximately perpendicular falls, at Bern and Gryon, and the observation of a bolide passing at an angle not stated, at a point which makes a triangle with the two former localities, suggest that a meteorite had burst at so great a height in the atmosphere that no sound of explosion reached the surface of the earth, and had scattered its fragments so as to cover

* See also "*Note sur le bolide du* 20 *juin*, 1890," par H. G. Fordham.—'Bulletin de la Société Vaudoise des Sciences Naturelles,' 3e série, vol. xxvii, No. 104, p. 220.

† 'Trans. Herts Nat. Hist. Soc.,' Vol. V, p. 33.

‡ '*La Gazette de Lausanne*,' 23rd and 24th June, 1890; '*Le Genevois*,' etc.

the wide area defined by the observations. The facts are, unfortunately, bare, and the deductions from them consequently of no great value: to us their interest is simply relative, so far as they go to show that the phenomena of the 20th of November, 1887, are by no means unique, but may be observed more or less frequently in different parts of the world.—*H. George Fordham, Lausanne, Switzerland.*

Read at Watford, 13th April, 1891.

A Fire-ball Meteor seen in Hertfordshire.—At our meeting at St. Albans in December, a letter from Dr. Brett was read, stating that a brilliant meteor had been seen by his dispenser and his gardener at Watford at about half-past nine on the night of Sunday, the 14th of December. This meteor was also seen by several persons in the neighbourhood of St. Albans, and all state that it was something like a flash of lightning, and that the light was bluish. It is also reported to have been seen at Hertford, but I have not heard of its having been observed elsewhere in Hertfordshire. It was, however, seen at many places in England wide apart, and accounts of it have been given in 'Nature,' in Symons' 'Meteorological Magazine,' and in the 'Essex Naturalist.' It was seen as far north as Hodsock in Notts, as far north-east as Bury St. Edmunds in Suffolk, as far south-east as Ramsgate in Kent, and as far west as Redbourn Bury, three miles north-west of St. Albans, in Herts. Its path appears to have been from north to south, over Cambs, Essex, and Kent, and therefore it must have pursued a very different direction from that of the meteorite of the 20th of November, 1887, of which Mr. Fordham gave such a very complete account in our 'Transactions.'* The time of its appearance seems to have been between 9.40 and 9.45 p.m., and it was therefore dark, but the meteorite of 1887 was seen at 8.20 a.m., and therefore in broad daylight, also on a Sunday. That, however, was rather heard and felt generally, than seen, giving to most people the impression of an earthquake, and as such it was first reported, while only two persons saw it. The recent meteorite was taken by several for a flash of lightning, and one observer posted a thunderstorm form to the Royal Meteorological Society immediately he had seen it, only finding by the accounts in the papers the next morning what it really was. It gave a light so vivid that it appeared for a few seconds almost as light as day. No observers seem to have heard any noise or felt any disturbance of the air. It is reported by Dr. Brett's gardener to have been "forked and red and blue *when it burst*, just like a sky-rocket, vanishing directly." His dispenser states that it was "like an electric light, of a bluish colour, and only lasted a few seconds."

An exhaustive examination of the phenomena attending the appearance of this meteor is being undertaken under the auspices of the Royal Astronomical Society, and a very interesting report will doubtless be published by that Society. Pending its issue it would

* 'Trans. Herts Nat. Hist. Soc.,' Vol. V, p. 33.

be futile to attempt to offer any explanation of the phenomena beyond the fact that it is evident that one of the innumerable meteorites traversing space, having come too near our earth for its own safety, has been dissipated by the intense heat caused by the frictional resistance of our atmosphere to its passage through it, its momentum, thus converted into heat, adding a little to our stock of energy in the form of heat, and its matter, perhaps in great part vaporised, adding a little to the mass of our earth and atmosphere.*—*John Hopkinson, St. Albans.*

Botany.

Poisonous properties of Primula obconica.—As I believe that it is not generally known that *Primula obconica*, one of our prettiest greenhouse plants, has poisonous properties, I have collected some information with regard to it, and I exhibit a plant kindly lent to me for the purpose by the Earl of Essex. The subject was first brought under my notice by Dr. Fisher, of King's Langley, who showed one of these plants and explained its properties at a recent meeting of the West Herts Medical Society. Last year he attended a lady who suffered from a painful rash on her hands which he determined to be neurotic urticaria. *Primula obconica* was one of her favourite flowers, being largely used by her for table-decorations, and she noticed that she always had the rash after handling it. On one occasion after doing so she had shivering attacks in the night, found the rash the next morning, and continued ill for a week. When from home she was quite well. She was first told that the plant was poisonous on the 23rd of August, but did not believe it, as it was at least twelve hours after handling it that the rash came. A month after this she purposely plunged one finger into the plant, and the following day Dr. Fisher saw that finger alone attacked. Since then she has banished the plant from her house and there has been no return of the rash. Mr. J. W. Odell has sent to me the following account of his experience of the effects of this plant at Mrs. Brightwen's, The Grove, Stanmore. "I have grown *Primula obconica* for six years or more, and for several seasons I was subject to a very troublesome skin disease, the skin being violently irritated and blistered. I was advised that this was probably due to contact with the leaves of the suncake (*Rhus toxicodendron*), but I found that it was due to *Primula obconica*. That this plant has poisonous properties is beyond a doubt, but whether these are in the glandular

* The following, from a little book entitled '*Mirabilis Annus Secundus*, or the Second Year of Prodigies,' published in 1662, probably relates to a somewhat similar meteor seen in Hertfordshire. The after-light may have been caused by reflection from clouds when the meteor itself had disappeared from sight. "An inhabitant of Abbot's Langley in Hertfordshire, by trade a carpenter, going abroad some hours before day, on the 6th of January, 1661, it being exceeding dark, on a sudden saw in the east the appearance of some light, and immediately after (as he conceived) the sun arose; but after a very short time there was no appearance at all of it, and it was as dark as before till the usual time of the day-break. The party affirms the truth of this to all that speak with him about it, from some of whom this information comes."

hairs or in the sap I cannot say. I am inclined to think that the sap is poisonous, having found that after breaking off leaves and re-potting the plants I have had a sharp attack of the irritation. It does not affect every one the same: we grow it here in quantities, but the young man who is looking after the plants now is never troubled with any effects from it. I have tested the fluid in the blisters with litmus-paper, and I find that it gives an acid reaction. *Primula obconica* is a native of South and Central China, and was first introduced here under the name of *Primula poculiformis*." Mr. Darby of Watford tells me that one of his men cannot work in the greenhouse where this plant is grown, but that other men are not affected by it. I have examined the leaves under the microscope, and I find that their hairs are similar in appearance to those of the stinging-nettle.—*A. T. Brett*, [*M.D.*,] *Watford.*

Zoology.

Insects building in a Lock.—A locksmith in Watford was asked to put a large lock in order, and in taking it off the door to repair he found it to be full of the eggs of some insect. It was in the winter, and he said that a common housefly flew out of the lock. I examined the lock and found it to be full of cells, not formed of wax, but of wood or pith, and leather-like in texture. They were not so regular as those of the bee. Some of them were open, and in them I could see larvæ wagging their heads about in a very grotesque manner. Mr. Arthur Cottam thought they were the cells of the common housefly. Miss Ormerod informed me that some years ago she had found several Hymenoptera establishments in locks in chests of drawers in rooms not in use, and she believed that the nests were those of *Odyneri*. One species of *Odynerus*, she said, is stated to have set up its house on one occasion in a pistol.—*A. T. Brett*, [*M.D.*,] *Watford.*

Stoat caught in a Mole-trap.—Mr. T. Durrant, of Knightlands Farm, Barnet, early in February (1891) caught a large male stoat *(Mustela erminea)* in a mole-trap. The animal had evidently been pinched for food, and had sought it among the subterranean passages excavated by moles. I thought this a very interesting circumstance, and worth recording.—*W. Lewis, Barnet.* (*Communicated by Dr. Brett.*)

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APPENDIX.

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May, 1892.

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1881 Hill, William, F.G.S., *The Maples, Hitchin.*

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1889 Lane, Mrs. Quincey, *Berkhamsted.*
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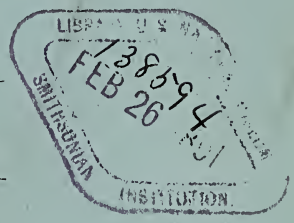

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